The Relationship between Unconventional Monetary Policy and Uncertainty at the Zero Lower Bound in the EMU: Evidence from a SVAR Methodology

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Abstract

The main refinancing operations rate has been stuck at the zero lower bound for more than three years and the European Central Bank has engaged in unconventional monetary policy to provide stimulus to the economy. Using structural vector autoregressive models, this thesis addresses the question whether the unconventional monetary policies in the European Economic and Monetary Union (EMU) between 2007 and 2019 affected stock market uncertainty. A loosening monetary policy, measured by target balances, decreases uncertainty within the EMU. This reaction is found to be more pronounced among southern European countries than among the non peripheral countries. Further, I provide evidence for a significant drop in uncertainty in Italy, Portugal, and Spain considering the launch of the outright monetary transactions Program (OMT) and the Securities Markets Program (SMP).

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Contents

List of Tables

List of Figures

1 Introduction

Prior to the financial crisis in 2007, only very little attention was paid to the European Central Bank (ECB) and its operations. Only some investment professionals took a quick glance at Frankfurt every six weeks when the governing council informed about their latest monetary decisions. However, after the burst of the housing bubble in the U.S. and the default of Lehman Brothers in 2008, things began to change dramatically. In response to the turmoil after the bankruptcy and bail out of several financial institutions, investors began to question the risk profile of their portfolios and the underlying securities. Uncertainty suddenly shot up and banks as well as individual investors began to mistrust each other. As a consequence, lending between counterparties was ceased. Due to an increasing globalization and financial integration, many European banks had bought defaulting securities from the U.S. banks. Consequently, the crisis was not limited to the north American market but it rather spilled over to the Euro area. During this period, values of multiple assets crashed worldwide, credit markets dried out and balance sheets deteriorated. Many governments in the Euro area had to launch bailout programs for their national financial institutions.

However, while the banks still had to struggle with the aftermath of the crisis, the Economic and Monetary Union of the European Union (EMU) was hit by another crisis in 2010, that was later known as European debt crisis. Economists agree that there was no single cause for the crisis but rather that many different reasons, including easy credit conditions, the previous crisis in 2008 and international trade imbalances. As a response to the financial and European debt crisis, the ECB began to implement its own operations. In order to boost credit lending between banks, the governing council of the ECB decided to gradually lower its main refinancing operations (MRO) interest rate. This decision did not only affect the dried out credit markets but rather helped the ECB to achieve its primary goal of price stability. Decreasing interest rates were supposed to provide easy access to cheap financing such that companies in the economy could increase their output and thus tackle the problem of deflation that was present at the time. Nonetheless, after the governing council lowered interest rates to zero per cent in 2016 and thus reached the zero lower bound (ZLB) it still could not see an adjustment in the path of inflation towards its target rate of below but close to two per cent, the ECB decided to engage in unconventional monetary policy measurements.[1] This mainly included large-scale asset purchases. However, Bloom (2009) shows that uncertainty plays a crucial role in the transmissions mechanism of non-standard monetary policy. If uncertainty is high, credit markets are dysfunctional because banks

[1] See ECB Press Release March 10, 2016

would not engage in business with each other anymore (Allen et al (2009)). As a result, the transmission mechanism could be harmed and interest rate cuts are not passed through to the real economy. Consequently, in order to achieve its desired effects, the ECB needs to make sure to lower uncertainty when implementing unconventional monetary policy measurements. If uncertainty remains unchanged, non-standard actions might not unfold any effect on the real economy. Reducing uncertainty should in theory not only have favorable effects on output and price stability but should also help in restoring dried out credit markets.

Hence, in this thesis, using structural vector autoregressive (VAR) models, I attempt to shed light on whether unconventional monetary policy can affect and significantly reduce uncertainty in member countries of the EMU. Consequently, I also aim to examine the relationship between uncertainty and output of an economy. Further, subordinated to this, I will also study possible spillover effects from the monetary policy decisions taken by the FED onto the real economy in the EMU to make sure that all primary drives of uncertainty changes are explained.

Moreover, the EMU and the Euro area are characterized by a high degree of heterogeneity (Angeloni and Ehrmann (2003)). Even though the member countries share a common currency, they all have different kind of fiscal policies as well as find themselves at different stages in the economic cycle such that unconventional monetary policy might has a different effect across the countries. While the countries in the southern European area such as Greece, Italy, Ireland, Portugal and Spain (GIIPS) were in a downturn, non-peripheral countries such as Germany and France were on the top of the cycle. In addition, since the GIIPS countries showed also large trade deficits and exorbitant levels of public debt they were hit significantly more by the crisis than countries in northern Europe. Therefore, the ECB had to put the peripheral countries at the heart of their interest when implementing non-standard measurements. I will, thus, examine differences in the effect of unconventional monetary policy on the individual member countries. In particular, I will distinguish between GIIPS and non-GIIPS countries to analyze whether the transmission mechanism fails in countries where it is needed the most.

With this thesis, I contribute to the vast growing literature on the impact of unconventional monetary policy on the real economy and asset markets during the crisis and post-crisis period. For instance, using structural VAR models, Wright (2012) shows that a loosening monetary policy shocks can decrease Treasury and corporate bond yields, but that those effects die off quite rapidly fast. Krishnamurthy et al. (2013) evaluate the effects of three

European Central Bank (ECB) policies. They examine individual effects for the GIIPS countries and find that some ECB policies lower yields in Italy, Spain and Portugal. Further the study Lutz (2013) shows that unconventional monetary policy shocks also have a large and adverse impact on investor mood. However, I most closely follow the approaches of Bekaert et al. (2013) who examined the effect of unconventional monetary policy on uncertainty in the U.S. between 1990 and 2010 and find that lax monetary policy decreases both risk aversion and uncertainty, with the former effect being stronger. Our approach is in so far unique as that I consider the crisis and the entire pre-crisis period up until 2019. Further, I are the first one who provides evidence for the EMU. Especially, our unique choice of proxying unconventional monetary policy enables us to deal with the heterogeneity.

In our thesis, I find that unconventional monetary policy lowers stock market uncertainty within the EMU. This coincides with the findings of Bekaert et al. (2013) and Wright (2012) who examined this relationship for the U.S. Secondly, due to the heterogeneity within the EMU, I also show that non-standard policy measurements transmit asynchronously to the member countries of the euro area. In particular, for most of the GIIPS countries I find that uncertainty decreases in the mid and long term after an initial increase within the first four months. Further, I provide evidence on the channels through which the ECB tries to implement its non-standard measurements. I show that the launch of the SMP program dramatically lowers volatility levels in all countries in our sample. The reaction is much more pronounced among the GIIPS countries than among the non-peripheral countries. Furthermore, I find that the effect of the OMT program shows a higher degree of heterogeneity among the countries and that the launch of the longer-term refinancing operations program leads to an increase in volatility in most of the countries or has an insignificant impact.

The remainder of this thesis is structured as follows. Chapter 2 starts off explaining the mathematical ideas behind monetary policy. Subsequently, what are the possibilities as soon as the interest rate cannot be seen as a valid tool anymore? Followingly, I will analyze to what extent theory failed in practice during the last decade and what actions the ECB has taken as a response. Chapter 3 begins with the foundations of vector autoregressive models as well as structural vector autoregressive models. By doing so, this thesis will lay down the approach of how the effect of monetary policy shocks on stock market uncertainty in the EMU between 2007 and 2019 is measured and how the decisions of the FED spilled over to the European market. Lastly, I will show through which channels the ECB specifically affected the market receptions. Chapter 5 summarizes the results of our analyses. Chapter 6 concludes.

2 Conventional and Unconventional Monetary Policy

In this chapter, I will start off by explaining the mathematical ideas behind monetary policy. Why does the ECB use the short term interest rate as their instrument to ensure price stability and how does it determine the optimal interest rate to achieve its goal? Subsequently, what are the possibilities as soon as the interest rate cannot be seen as a valid tool anymore? Lastly, I will analyze to what extent theory failed in practice during the last decade and what actions the ECB has taken as a response.

2.1 Conventional Monetary Policy

When the ECB was first established in 1998, its primary mandate "*to maintain price stability within the Eurozone*" was set out in Article 127 (1) of the Treaty on the Functioning of the European Union.[2] The price stability is usually represented by the inflation rate which can be derived from the Harmonised Index of Consumer Prices (HICP). The HCIP measure the change in prices of consumer goods and services.

Until some years ago, measuring monetary policy was straight forward. One could easily take the short term interest rate as proxy (Bernanke and Kuttner (2004)). The reason for this is that price stability is the primary mandate of the ECB. Thus, the ECB sets itself a target inflation rate at below but close to two per cent.[3] To illustrate this analytically, consider the following example. An investor who invests his money over n periods at the interest rate $i_{n,t}$, receives

$$(1 + i_{n,t})^n \tag{1}$$

Similarly, an investor who invests his money n times for one period receives

$$(1 + i_t)(1 + i_{t+1})...(1 + i_{t+n-1}) = \prod_{i=0}^{n-1}(1 + i_{t+i}) \tag{2}$$

Due to arbitrage free markets the following must apply

$$(1 + i_{n,t})^n = \prod_{i=0}^{n-1}(1 + i_{t+i}) \tag{3}$$

[2]See Article 127 of the Treaty on the Functioning of the European Union

[3]The ECB's Governing Council adopted a quantitative definition of price stability in 1998: "Price stability is defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below 2%."

Applying the logarithm[4] we obtain

$$i_{n,t} = \frac{1}{n} \sum_{i=0}^{n-1} i_{t+i} \tag{4}$$

It follows that the long term interest rate equals the average of the short term interest rates. The ECB can thus influence the long term interest rates by changing the short term interest rates. This is a crucial implication for monetary policy. Assuming now a two period example results in

$$(1 + I_t)^2 = (1 + i_t)(1 + i_{t+1}) \tag{5}$$

Since the interest rate in the future is unknown one has to form expectations on it

$$(1 + I_t)^2 = (1 + i_t)(1 + E_t i_{t+1}) \tag{6}$$

Therefore, a second crucial implication for monetary policy is that the long term interest rates depend on the expectations on future short term interest rates. To see the connection between the inflation and the implications that were shown above, recall that

$$i_t = r_t + E_t \pi_{t+1} \tag{7}$$

where π denotes the inflation rate. For a n-periodic interest rate, it follows

$$\begin{aligned} i_{n,t} &= \frac{1}{n} \sum_{i=0}^{n-1} E_t i_{t+i} && (8)\\ &= \frac{1}{n} \sum_{i=0}^{n-1} E_t r_{t+i} + \frac{1}{n} \sum_{i=0}^{n-1} E_t \pi_{t+i+1} && (9) \end{aligned}$$

It applies

$$\begin{aligned} \sum_{i=0}^{n-1} \pi_{t+i+1} &= (p_{t+1} - p_t) + (p_{t+2} - p_{t+1}) + (p_{t+3} - p_{t+2}) + ... + (p_{t+n} - p_{t+n-1}) && (10)\\ &= p_{t+n} - p_t \equiv \tilde{\pi}_{t+n} && (11) \end{aligned}$$

[4] $ln(1 + x) \approx x$

We can rewrite this to

$$i_{n,t} = \frac{1}{n}\left(\sum_{i=0}^{n-1} E_t r_{t+i} + E_t \tilde{\pi}_{t+n}\right) \tag{12}$$

If the real interest rate fluctuates around a constant value $\bar{r}$, it follows

$$i_{n,t} = \bar{r} + \frac{1}{n} E_t \tilde{\pi}_{t+n} \tag{13}$$

I can therefore conclude that long term interest rates mirror the ECBs expectations on inflation. Thus, by changing the short term interest rates, the ECB automatically connotes their expectations on the long term interest rates and therefore on the future inflation rate. If the ECB expects a inflation level that it considers as too high (low), it will raise (cut) the short term interest rates.

2.1.1 Taylor Rule

Given an inflation target of below but close to two per cent, it is the challenge of the ECB to determine the appropriate interest rate. Throughout the years, economists have developed several tools to do so. The most common approach these days, however, is the model proposed by Taylor (1993) and hence called *Taylor Rule*. It can be described as

$$i_t = \pi_t + \phi_y(y_t - \bar{y}_t)\phi_\pi(\pi_t - \pi^T) + r^* \tag{14}$$

where r^* denotes the real interest rate, π^T the target inflation and $\bar{y}_t$ the natural output rate. Since the numerical values for the coefficients are around 0.5 for the U.S economy I will use them for illustration purposes as well. Therefore, the Taylor rate depends on the deviation on the current inflation from the desired level as well as from the output gap which is the percentage deviation of the output from its natural rate (Clarida (1998)). By rewriting the equation to

$$i_t = -0.5\pi^T + r^* + 1.5\pi_t + 0.5(y_t - \bar{y}_t) \tag{15}$$

one can see that the inflation weighs more than the output. The implications of that are very straight forward. If the inflation is relatively too high, the central bank should, ceteris paribus, increase their interest rate and vice versa. If the economy is overheating, increasing interest rates can reduce investment and consumption activities and thus have a deflationary effect (Woodford and Walsh (2005)). Moreover, if the output gap is substantial, which implies that the economy currently acts below his potential, the central bank should reduce the interest rates. Consequently, financing is becoming cheaper and companies can invest and produce more as well as increase their workforce. Due to some weaknesses of the model, researches came up with several extensions such as Clarida (1998). The main implications of the models, however, widely remain the same.

2.1.2 Transmissions Mechanisms

We now have seen, that, in the context of conventional monetary policy, the ECB directly sets the short term interest rate to a desired level. This eventually affects the financing costs of companies which determines in/output of the economy and thus the inflation rate. But how does this exactly work? What are the main channels through which a change in the interest leads to a change in inflation? Since there many channels, I will attempt to shed light on the most important ones. Those channels should not be seen as conflicting with one another but rather complementary.

One of the most mentioned channels is the *interest rate channel*. The official short term interest rate is a key measure for the interbank money market. A change in the interbank money market rate changes the yield curve. Given the assumption of well functioning and competitive markets, this will ultimately result in changes for deposit rates, borrowing rates as well as bond yields. Assuming price rigidites, a change in the nominal interest rate will have real effects. First, following an increase in the short term rate the capital costs for companies will increase, since borrowing is now more expensive. According to Modigliani and Miller (1958) this increases the required rate of return of a project and decreases the likelihood to realize it. Overall investment in the economy would decrease and deflationary tendencies would emerge. Second, one can observe a substitution effect which describes that the current price of consumption relative to the future price increases. When consumption is more expensive today, people will shift their consumption into the future, creating a deflation today. Last, one can also notice an income effect which captures the change in income of the creditors relative to the debtors.

Further, *exchange rates* work as a second channel. An increases in domestic interest rate makes the domestic currency more attractive to foreign investors. Consequently, the domestic currency appreciates nominally. Again assuming price rigidites in the short run, this also causes a real appreciation (depreciation). Domestic products and services getting relatively more expensive in comparison to the rest of the world. Since products and services are more expensive domestic units will have to export less and import more. A higher import of cheap products will ultimately decrease the inflation rate.

Thirdly, an additional channel is commonly associated with *Tobin's q theory*. Tobin's q describes the ratio between the market value of physical assets and its replacement value (Kaldor (1966)). Expansionary monetary policy (i.e. a reduction in the interest rate) will lead to lower yield and thus higher asset prices. This not only include bonds but also stocks or real estate. Due to this general increase in wealth, overall consumption will also rise. Consequently, a higher Tobin's q indicates a high return of investment such that companies will increase their investments.

The last channel that should be mentioned is the the *credit channel* which can be divided into a balance sheet channel and a bank lending channel (Bernanke and Gertler (1995)). While the other channels assume a frictionless capital markets, the credit channel is explicitly built on the capital market friction. It should be rather considered as a complementary channel. The basic idea is that effect of monetary policy is reinforced by a change in the external finance premium (EFP). EFP captures the difference between costs of external and internal financing[5]. Without any frictions, EFP would be zero. To see how monetary policy influences EFP I will first consider the balance sheet channel which claims that monetary policy affects the balance sheet and the cash flows of debtors. On one side, an increase in interest rates decreases the market value of assets and thus the value of the collateral. On the other side, the costs of borrowing will also rise which leads to lower cashflows. Hence, an increase in interest rates will negatively affect the balance sheet of a company. Since the financial position of the company got worse (e.g. decreased net assets), the EFP will ultimately go up and investments will be considered as too expensive and the volume will be dampened (Bernanke and Gertler (1995)). Furthermore, the bank lending channel describes the relationship between monetary policy and the amount of loans offered by the banks. This is especially crucial for Europe, where corporate financing is primarily done through banks. Open market sales reduce the reserves of the bank increase the financing costs. This leads to a shift in credit supply and the EFP climbs. The same also holds vice versa of expansionary monetary policy.

2.2 Unconventional Monetary Policy

The previous subsection showed how the ECB uses the interest rate to reach its target inflation rate. However, since the official short terms rates reach the zero lower bound

[5] Cost of external financing = Cost of internal financing + EFP

(ZLB) at the end of 2014, the ECB could no longer use the interest rate as their tool to reach its inflation target since further interest rate cuts were not possible anymore. Looking again at the Taylor Rule and exclude the possibility of negative interest rates we can write equation (14) as

$$i_t = max[\pi_t + \phi_y(y_t - \bar{y}_t) + \phi_\pi(\pi_t - \pi^T) + r^*, 0] \tag{16}$$

Thus, the zero lower bound implies non-linearity in the transmission mechanism. One can determine the inflation rate, π_t^{ZLB}, for which the ZLB is reached by solving equation (16), given that $\phi_y = 0$

$$\pi_t^{ZLB} + r^* + \phi_\pi(\pi_t^{ZLB} - \pi^T) = 0 \tag{17}$$
$$\pi_t^{ZLB} = \frac{\phi_\pi}{1+\phi_\pi}\pi_T - \frac{r^*}{1+\phi_\pi} \tag{18}$$

Therefore one can identify three crucial factors that determine the critical inflation rate π^{ZLB}:

- The higher the inflation target π^T, the higher π^{ZLB}
- The higher the real interest rate r^*, the lower π^{ZLB}
- An increase in ϕ_π implies a higher π^{ZLB}

We can apply these findings to an dynamic aggregate demand (DAD) and supply (DAS) model. In this special case, the IS curve is given as

$$y_t = \bar{y}_t - a(r_t - r^*) + u_t \ \ , a > 0 \tag{19}$$

We can combine the Fisher equation (Fisher (1930)) and adaptive expectations to obtain

$$r_t = i_t - E_t\pi_{t+1} \tag{20}$$

Inserting equation (20) into equation (19) results in

$$y_t = \bar{y}_t - a(i_t - \pi_t - r^*) + u_t \tag{21}$$

If now insert equation (17) and rearrange we obtain the DAD curve for the case $\pi_t > \pi^{ZLB}$

$$y_t = \bar{y}_t - a\phi_\pi(\pi_t - \pi^T) + u_t \tag{22}$$

However, if $\pi_t < \pi^{ZLB}$ then the interest rate i_t is zero and our DAD curve is

$$y_t = \bar{y}_t + a\pi_t + ar^* + u_t \tag{23}$$

The impact of the inflation rate on the output changes at the ZLB. Above π^{ZLB} a higher inflation leads to a decrease in the output while below π^{ZLB} a rising inflation boosts the output, meaning that the DAD curve has a positive slope in this area.

Changes in inflation expectations results in even higher changes in the actual inflation rate. Since this only applies at the ZLB, it refers to decreasing inflation rates. In addition, due to a positive relationship of output and inflation at the ZLB, one can also notice reducing numbers in the economic output creating a "downward spiral". In such a scenario the deviation of the inflation expectation from the target inflation are now permanent and not only temporary. This is commonly known as the liquidity trap. As a result, the central bank needs to control the inflation expectations of the economy. The credibility of the ECB is now their most powerful contraption. The two most common tools for credibility used by the ECB are *forward guidance* and *quantitative easing (QE)*.[6]

Firstly, forward guidance tries to reduce the short term interest rates for a considerable period of time to have an effect upon the long term interest rates. The central bank tries make predictions or self-commitments on their own future policy to influence interest rate expectations. One usually distinguishes between odyssean forward guidance and delphic forward guidance. While odyssean forward guidance describes a state-dependent commitment on future policy delphic forward guidance is rather a prediction and not a commitment on future policies. The idea behind that is that the long term interest rate determines today's output. If the ECB can manage to reduce the long term int rest rate by using forward guidance, it already has expansionary effects today. Since forward guidance is based on expectations it is difficult to quantify it. Moessner (2013) studied the relationship between policy rate guidance announcements of the Federal Open Market Committee (FOMC) and Eurodollar interest rate futures. He finds that they significantly reduced implied interest rates and led to a flattening of the yield curve. Further in an extension to this, Moessner (2014) finds that explicit FOMC policy rate guidance announcements at the zero lower bound led to higher equity prices in a number of advanced and emerging economies.

[6] Further, Bernanke proposed for Japan to temporarily override their inflation target and to aim for a higher inflation rate.

Secondly, QE is a term referred to a scenario where the central aims to expand the monetary base or to alter its composition. Japan was the first country that applied QE between 2001 and 2006. After the financial crises the QE became also the tool of the Bank of England and the Sveriges Riksbank. In 2015, the ECB also began to engage in QE. It mostly consists of purchases of securities. These can include, for instance, private mortgage backed securities (MBS), asset backed securities (ABS) or sovereign bonds. The aim is to reduce the long term interest rates by further strengthening their policy announcements through actual purchases. However, the mechanism of that is quite complicated. Cochrane (2014) stated that "*QE is a curious experiment, as standard theory makes a pretty clear prediction about its effects: zero*". The reason for this is that the price of a security are simply the discounted cashflows. It does not matter who actually holds the security. If the ECB buys a high amount of these securities, their price will increase sharply and will be seen as relatively overvalued by investors who then in turn sell their holdings since relative evaluation matters (Damodaran (2015)). Eventually the net demand is unchanged as well as the price. Therefore, certain assumptions need to be made.

Firstly, assuming that securities are no perfect substitutes, the purchases of the ECB are not completely neutralized by the sells of the private investors. This is plausible in so far as some institutional investors need to hold a certain amount of sovereign bonds in their portfolios. Due to the the decreasing yields in sovereign bonds, investors will alter their portfolio composition and will, for example, buy corporate bonds. Thus, QE does not only influence sovereign bonds but rather all assets. This results in better refinancing possibilities for companies. This mechanism is commonly referred as to the balance sheet channel (Bernanke and Gertler (1995)).

Secondly, buying ABS or MBS, significantly reduces pressure on the balance sheet of the banks. The banks then need to hold less regulatory capital and have more money available to give credits which should boost a slowing economy. However, one problem that occurs is moral hazard. Banks might lose the incentive to monitor the loans they give to their customers, since the ECB will buy ABS anyway.

Lastly, QE also works through the exchange rate channel, described above. Lowering the long term interest rates makes the home currency relatively less attractive to foreign investors and eventually has a depreciating effect. Given certain assumptions, it follows a rise in exports and thus a stimulation economy.

2.3 Application in the European Monetary Union

This subsection provides an overview about the monetary policy which was implemented by the European central bank from the financial crisis in 2009 up until today. Since there were partly significant breaks in the policy, I will divide this section into three parts: conventional and unconventional monetary policy as well as target balances.

2.3.1 Conventional Monetary Policy

As can be inferred from figure 1, the general paths the short term interest rates are coinciding in the EMU and U.S. However, the short term process in the EMU follows the U.S. with a lag of approximately four years. While the U.S. reached the ZLB in late 2009, the ECB even increased its official interest rate from by 25 basis points in April 2009 followed by another 25 basis points increase in July 2011. On July 5th 2012, the ECB council announced in a press release for the first time ever that it would cut the interest rate on the main refinancing operations of the Eurosystem to below one per cent setting the new target rate at 75 basis points. The council primarily justified his decision with a weak economic growth in the euro area and higher heightened uncertainty weighing on confidence and sentiment.[7] In addition, the ECB also tried to ensure solvency of the books as well as to boost the growth of loans to the private sector which declined prior to the announcement. The next interest rate cuts of 25 basis points each were decided in May and November 2013 on the grounds of price pressure, weak economic sentiment and a declining output for five consecutive quarters. According to estimates the annual inflation rate in the euro area declined by 50 basis points to 1.2 per cent in April 2013. Further, ECB President Mario Draghi explained that the fixed rate full allotment policy will represent liquidity insurance for the banking system.[8]

Finally, after another drop to five and 15 basis points in June and September, respectively, the ECB reached the zero lower bound in March 2016 when they lowered the interest rate on the main refinancing operations of the Eurosystem by five basis points to zero with effect from March 16 onward to fight the deflation tendencies in the euro area that were present at the time.[9] This was the first time since its establishment that ECB cut the interest rates to zero percent. Similar reasons such as a downward tilted economic growth were given as reasons for this decision. Due to the heterogeneity in the euro area and multiple fiscal policies, the member countries found themselves at different positions in the economic cycle. While countries like Germany were at a slight boom, the countries in the southern

[7] See ECB Press Release July 5, 2012
[8] See ECB Press Release May 2, 2013
[9] See ECB Press Release March 10, 2016

parts in Europe showed severe threats of a recession. Since the ECB always need to look at its weakest members, the drop in interest rates were supposed to help GIIPS countries to refinance their debt levels.

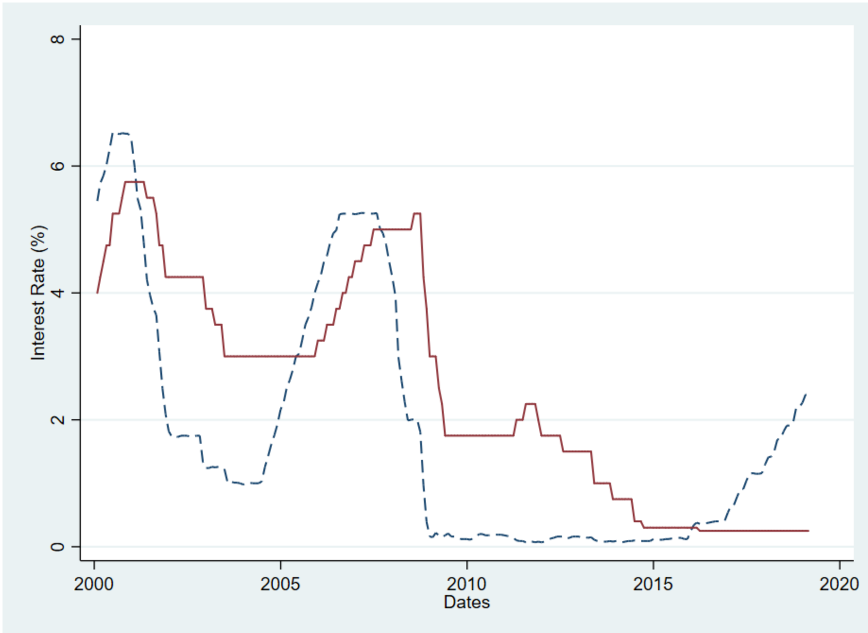

Figure 1: This figure shows the development of the FED Funds Rate (dashed line) and the marginal lending rate for the main refinancing operations set by the ECB (solid line).
Source: European Central Bank, St. Louis Federal Reserve

2.3.2 Unconventional Monetary Policy

As explained in subsection 2.2, once reaching the zero lower bound, the ECB was no longer able to use its interest rates as their primary tool. In addition to the events and decision regarding standard policy measures that were shown in the previous section, the ECB also commenced to implement non standard instruments. Attinasi et al. (2009) point out that one should to see this process in connection with the global financial crisis in 2007 and the subsequent European debt crisis. The bursting of the housing market bubble and the eventual default of Lehman Brothers in 2008 had severe spillover effects on the euro area. Firstly, many European banks, no matter of which size, were engaged in structured securities, called mortgage-backed securities (MBS). The name already implies that the underlying assets were mainly mortgages from U.S customers. Thus, the value of those securities heavily depends on the mortgage cash flow made by the borrowers. After interest rates rose, many credit holders could no longer repay and their mortgage and the loans were inevitable to default. As a consequence, the MBS's lost significantly in value and banks in the U.S but also in Europe had to write off the values in their balance sheets. In order not to default, many of those banks had to be bailed out by their national governments.[10] Secondly, the impact on the countries in Europe were intensified due to the fact that most of the European countries have a negative trade balance meaning that they export more than they import.

However, the euro area did not only suffer from the spillover effects of the financial crisis but also from an internal crisis as explained by (Sinn and Wollmershäuser (2011)). The authors describe the problem as a *imbalance of payments* that has been caused by the accounting system of the National Central Banks (NCBs), also known as target balances. Those target balances can be seen as classical balance of payments surpluses and deficits. The ECB allowed and backed NCBs of the periphery countries in creating and lending an exorbitant amount of money. Sinn and Wollmershäuse (2011) show that major parts of the current account deficits of the GIIPS countries are financed by target credits between 2008 and 2010. By September 2011, the difference in target balances between Germany and the accumulated rest of the Eurozone was about 450 billion euros which raises concerns about the vulnerability of the heterogeneous system within the euro area. Investors shifted their money to more safer countries such as Germany, causing government bond spreads between the Bund and the GIIPS countries to skyrocket. Further, the periphery countries had difficulties to maintain a healthy access to liquidity. The ECB needed to implement non-standard instruments through which it was able to provide a certain amount of liquidity while ensuring that deficit countries where able to refinance its debt. The timeline of the non-standard policy measures can be seen in table 1.[11] The first action was taken in May, 2009 when a covered bond purchase program (CBPP1) was announced under which the ECB bought euro-denominated covered bonds issued in the euro area. One year later, May 2010 marks an important day as the ECB introduced their Securities Market Program (SMP) and with that laid the foundation of extensive purchases in the secondary market. The goal was "*to ensure depth and liquidity in those market segments which are dysfunctional. The objective of this program is to address the malfunctioning of securities markets and restore an appropriate monetary policy transmission mechanism.*"[12] Parallel to this decision, the ECB also announced that it had agreed on a full allotment policy for its longer-term financing operations (LTRO). This ensured that banks continued having an easy access to liquidity and further decreased default risks.

[10] For a detailed description and analysis of the crisis see Reinhart Rogoff (2008)
[11] Due to simplicity, I will refrain from mentioning each event but rather only the crucial ones.
[12] See ECB press release May 10, 2010

Afterwards, the ECB kept lowering minimum reserve rates and the requirements for financing operations. This was especially important for the GIIPS countries as the main source for liquidity was now the national central banks together with the ECB. When it seemed that those initiatives were not sufficient enough to keep investors confident, Mario Draghi gave his probably most famous speech in London on July 26, 2012. "*Within our mandate, the ECB is ready to do whatever it takes to preserve the euro; and believe me, it will be enough.*"[13]. Economists regard this speech as forward guidance at its best (Alcaraz et al. (2018)). On that day, Italy's and Spains 10-year bond yields decreased by almost 40 bps and 45 bps, respectively. The reaction of the short term bonds was even more significant with bond yields decreasing by almost 90 bps and 75 bps in Italy and Spain respectively. Speculations that Italy was in severe troubles or that the EMU could even collapse were broke off instantly. Followingly, the ECB announced its outright monetary transactions (OMT) program under which it keeps the option open to buy sovereign bonds issued by Eurozone member states.[14] As of 2019, no bonds have been bought under this program. However, solely the announcement of this program had significant effects on the bond market. The yields of periphery countries decreased and spreads narrowed (De Grauwe and Ji (2013)). In January 2015, the ECB eventually announced its latest major program. With the introduction of a new Public Sector Purchase Program (PSPP), the ECB started to buy government bonds of Eurozone member states. Together with a previously introduced ABS purchase program, the covered bond purchase program and a corporate sector purchase program, the PSPP represents one part of the Expanded Asset Purchase Program (EAPP). Initially, combined monthly asset purchases will amount to 60 billion euro until the ECB increased the amount to 80 billion euro in March 2016.[15] After seeing a desirable adjustment in the path of inflation, the ECB gradually lowered the amount of purchases within its asset purchase program.

Finally in June 2018, the governing council announced that they "*[...], subject to incoming data confirming our medium-term inflation outlook, will reduce the monthly pace of the net asset purchases to 15 billion euro until the end of December 2018 and then end net purchases.*"[16] However, the ECB will continue to invest the principal payments of the maturing securities for an extended period of time until they start rising key interest rates again. As of April 2019, the interest rate on the main refinancing operations, the marginal lending facility and the deposit facility are at 0.00, 0.25 and -0.40 per cent, respectively. According to estimates, the annual inflation rate in the euro are was 1.4 per cent in March 2019

[13]See Mario Draghi at the Global Investment Conference in London
[14]See ECB press release 2 August, 2012
[15]See press EBC release 10 March, 2016
[16]See ECB press release 14 June, 2018

(Eurostat).

Table 1
Unconventional Monetary Policy Timeline The table shows the most important events in the timeline of the ECBs unconventional monetary policy.

Event Date	Decision
07/05/2009	Announcement of Covered Bond Purchase Program (CBPP1): The ECB will engage in purchases of euro-denominated covered bonds issued in the euro area.
10/05/2010	Announcement of Securities Market Program (SMP) "to ensure depth and liquidity in malfunctioning segments of the debt securities markets and to restore an appropriate functioning of the monetary policy transmission. mechanism"
06/10/2011	Announcement of second Covered Bond Purchase Program (CBPP2): The ECB will keep engaging in purchases of euro-denominated covered bonds issued in the euro area.
26/07/2012	President Draghi gives his "whatever it takes" speech.
02/08/2012	Announcement of Outright Monetary Transaction (OMT): "The Governing Council may undertake outright open market operations of a size adequate to reach its objective."
05/07/2014	Outright purchases of ABS.
04/09/2014	Announcement of a third Covered Bond Purchase Program (CBPP3) plus an ABS Purchase Program (ABSPP).
22/01/2015	Announcement of an Expanded Asset Purchase Program (EAPP) which comprises ABSPP, CBPP3 and a new Public Sector Purchase Program (PSPP).
04/12/2015	Announcement of the extension of the period for the EAPP until the end of March 2017 or beyond.
10/03/2016	Announcement of the expansion of the monthly purchases under the EAPP from 60 billion to 80 billion euro.
14/06/2018	Announcement of the reduction to 15 billion euro and eventual termination of the EAPP at the end of December 2018.

2.3.3 Target Balances

After the start of the implementation of a more loosening monetary policy, one could expect the monetary aggregate base in the euro area to skyrocket as it did in the U.S. However, Sinn and Wollmershäuser (2011) show that the money aggregate base did not experience any massive fluctuations. Rather, it seems that the aggregate base follows its long term trend. Despite this finding, the ECBs purchase programs which promoted an expansionary policy did have significant effects on the member states of the euro area. These effects were captured by the so called target balances that are part of the balance sheet of the national central banks. Since each country has its own and independent central bank, target balances differ among the countries allowing us to analyze possible asymmetric effects. I thus take a close look at target balances and give reasons why the use of these balances to analyze the relationship between monetary policy and stock market uncertainty is recommended. Further, I want to explicitly point out that I use target balances solely for the purpose of analyzing asymmetric effects. This should not be seen as a personal view on whether the development of target balances are posing risks to the stability in the euro area or not.

Target2 is the abbreviation for the second generation of the Trans-European Automated Real-time Gross Settlement Express Transfer System. It is the internal payment accounting system of the Eurozone. It was implemented to enable an easier settlement for cross border transactions within the euro area. That is, EU banks can transfer money between each other in real time. To provide an illustration of the system imagine the following example.[17] Imagine a French customer wants to buy a product for 1000 euro from a German seller. The French customer would ask his bank to transfer the money to the bank of the German seller. However, the French bank cannot directly transfer the money to the German bank. This is where Target2 comes in place and functions as a intermediary settlement system. What happens now is, that the French bank of the customer transfers the money to its account which it has at the national central bank in France. Afterwards, the French central bank sends the money to the German central bank by using the Target2 payment system. In turn, the German Bundesbank books the money on the central bank account of the German private bank which then finally forwards the money to the bank account of the German seller. But why does this create imbalances in the national accounts? This is mainly due to accounting effects. During the transaction, Target2 does not actually exchange real money. Instead, the German central bank books a claim against the French central bank amounting to 1000 euro while on the other hand the French central bank books a liability against the

[17] This example was taken from the ECB website and expanded.

German central bank of the same amount. Important is that the claims and liabilities are never meant to be settled. Rather, it is assumed that they will cancel out each other at some point. Thus the sum of all liabilities and claims in the Eurozone should be equal to zero. Thus, target balances emerge from capital flows within the euro area.[18] Formally, target balances can be defined as

$$\Delta TARGET\ BALANCE = TARGET\ INFLOWS - TARGET\ OUTFLOWS \tag{24}$$

As can be seen from figure 2, the target balances were relatively small prior to the crisis in 2008. Only after the monetary implementations in response to the crisis, target balances began to rise. The reason was that during the crisis liquidity issues arised due to mistrust among financial institutions. Banks and investors began to doubt the financial stability of the southern European countries. Consequently, they started to shift their capital from riskier countries to more safe countries such as Germany.

Figure 2: The graph displays the development of the official target Balances of Germany (dashed line) against the combined target Balances of the whole EMU (solid line).
Source: European Central Bank Database

[18] Transactions within a country has no effect on the target balance of a national central bank.

3 Empirical Model

This chapter will start off with the foundations of vector autoregressive models as well as structural vector autoregressive models. Through doing so, I will lay down the approach of how the effect of monetary policy shocks on stock market uncertainty in the EMU between 2007 and 2019 is measured and how the decisions of the FED spilled over to the European market. Lastly, I will show through which channels the ECB specifically affected the market receptions.

3.1 Methodology

3.1.1 Vector autoregressive Models

Vector autoregressive (VAR) models can be described as a stochastic process which enables one to examine the relationship between multiple time series. Further, these models are also used to simulate a shock in certain variable and its effect on other variables that are of interest. For instance, one could use such a model to assess how a shock in interest rates would affect inflation or unemployment levels. Thus, VAR models can be seen as an extension to an AR(p) process by allowing a variable to not only be dependent on its own lagged value but rather also on other lagged values. Assuming a lag order of p=1, one can write the basic VAR model as

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 x_{t-1} + \varepsilon_{1t} \tag{25}$$

$$x_t = \beta_0 + \beta_1 x_{t-1} + \beta_2 y_{t-1} + \varepsilon_{2t} \tag{26}$$

where the covariance matrix of the error terms $\sum$ is

$$\sum = E(\varepsilon_t \varepsilon_t') \tag{27}$$

In this model the endogenous variables, y_t and x_t, both depend on their own value in $t-1$ as well as on each others lagged value. Assuming now that we have more than two time series but keep a lag order of p=1, allows us to rewrite our model the *reduced form*

$$\zeta_t = \phi_0 + \Phi_1 \zeta_{t-1} + \eta_t \tag{28}$$

where ζ_t describes an (n x 1) vector which contains the dependent variable of the time series. On the right side of the equation, ϕ_0 denotes also an (n x 1) vector which contains the intercepts of the n different time series. Φ_1 is a (n x n) matrix which captures the dependence between ζ_t and its lagged values ζ_{t-1}. Lastly, η_t is a (n x 1) vector describing an uncorrelated and unobservable sequence of error terms (Lütkepohl and Tsay (2010)). In order to obtain estimates of the coefficients Φ_1 and ϕ_0, I will assume multivariate distributed error terms.

To illustrate the idea behind the model, I follow the example of Lütkepohl and Tsay (2010). In this example I assume two time series $\zeta_t = (\zeta_1, \zeta_2)'$ and a lag order of p=1. This means, that the variables ζ_1 and ζ_2 only depend on its own lagged value in $t-1$ and on each others lagged value in $t-1$. To illustrate this scenario by one can use the following equation system:

$$\zeta_{1t} = \phi_{10} + \Phi_{11}\zeta_{1,t-1} + \Phi_{12}\zeta_{2,t-1} + \eta_{1t} \tag{29}$$

$$\zeta_{2t} = \phi_{20} + \Phi_{21}\zeta_{1,t-1} + \Phi_{22}\zeta_{2,t-1} + \eta_{2t} \tag{30}$$

We can see that the dynamic relationship between the two time series only hold if $\Phi_{21} \neq 0$ and $\Phi_{12} \neq 0$. In addition, the dependence on its own lagged value only holds if $\Phi_{11} \neq 0$ and $\Phi_{22} \neq 0$.

3.1.2 Structural Vector Autoregressive Models

Up to this point, I have not considered the case when a contemporaneous relationship between the variables exists. In such a case, one needs to multiply the vector with the dependent variables ζ_t with an (n x n) matrix A that describes the contemporaneous relationship between the endogenous variables.

$$A\zeta_t = \phi_0 + \Phi_1\zeta_{t-1} + \eta_t \tag{31}$$

When simulating a shock in one variable, one needs to keep other shocks constant. I thus need to make sure that the error terms are not correlated with each other. One can do this by defining the errors as a liner combination of structural shocks.

$$\eta_t = Bu_t \tag{32}$$

Without loss of generality I assume

$$E(u_t u_t') = I \tag{33}$$

Substituting equation (4.7) into equation (4.6) I obtain our SVAR model

$$A\zeta_t = \phi_0 + \Phi_1\zeta_{t-1} + Bu_t \tag{34}$$

For the two time series example the system could be as follows

$$\begin{bmatrix} 1 & a_{12} \\ a_{21} & 1 \end{bmatrix} \begin{bmatrix} \zeta_{1t} \\ \zeta_{2t} \end{bmatrix} = \begin{bmatrix} \phi_{10} \\ \phi_{20} \end{bmatrix} + \begin{bmatrix} \Phi_{11} & \Phi_{12} \\ \Phi_{21} & \Phi_{22} \end{bmatrix} \begin{bmatrix} \zeta_{1,t-1} \\ \zeta_{2,t-1} \end{bmatrix} + \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \end{bmatrix}$$

Since the relationship between the a dependent variable and itself should be equal to one. The goal is now to estimate the factors A, Φ_i and B.

3.1.3 Identification

In the process above, a_{12} and a_{21} represent the instantaneous relationship between ζ_1 and ζ_2. The structural VAR model has now a total of 10 unknowns consisting of eight parameters and two variances. This leads to the issue that the model has more unknowns (10) than actual equations (2). As a consequence, since I can not estimate the SVAR model directly, I must impose one restriction on the structural parameters since the estimation of the reduced-form VAR only results in nine parameters[19]. The usual approach is to impose restrictions on matrix A which is equivalent to imposing restrictions on the contemporaneous relations among the independent variables of the structural model (Lütkepohl and Tsay (2010)). This approach is called *identification*. There are two common ways for the identification. I will follow the approach of Bekaert et al. (2013) and apply a standard Cholesky decomposition of the estimate of the variance covariance matrix[20]. This has the advantage of allowing us to incorporate our own beliefs on the relationship among the endogenous variables. Since the dynamics between the endogenous variables are described by the off-diagonal coefficients of the variance-covariance matrix $\sum_{Cov}$, matrix A is constrained by $A^{-1}\sum_{Cov}(A')^{-1} = I$, where I describes an identify matrix. Given these constraints, by multiplying equation (4.6) with A^{-1} I obtain

$$\zeta_t = A^{-1}\phi_0 + A^{-1}\Phi_1\zeta_{t-1} + A^{-1}\eta_t \tag{35}$$

Defining $A^{-1}\phi_0 = \phi_0^*$, $A^{-1}\Phi_1 = \Phi_1^*$ and $A^{-1}\eta_t = \eta_t^*$ we can rewrite equation (4.7)

$$\zeta_t = \phi_0^* + \Phi_1^*\zeta_{t-1} + \eta_t^* \tag{36}$$

Gottschalk (2001) shows that the minimum number of required restrictions can be defined as the difference between the number of unknown and known parameters. Let n be the number

[19]With an estimation of the equations (4.4) and (4.5) we obtain nine parameters, that are six coefficients, two variances and one covariance.

[20]A second approach would be to set $B = I$ and let matrix A lower triangular

of variables in our hypothetical VAR model. As mentioned, since the diagonal elements of matrix A are all equal to one, matrix A has $n^2 - n$ unique unknown elements. Adding n unknown variances, the total number of unknown elements is $n^2 - n + 2 = n^2$. Further, from the estimation we obtain a total of $n^2 + n)/2$ coefficients. Taking the difference, our restrictions matrix requires at least $n(n-1)/2$ restrictions. Thus, a VAR model with two variables requires $2(2-1) = 1$ restrictions. Using maximum likelihood, I can then estimate the model.

4 Empirical Evidence

4.1 Data

To examine the effect of non-monetary policy shocks on stock market uncertainty for Germany, France, EMU and the GIIPS countries I follow the approach of Bekaert, Hoerova, and Lo Duca (2013) and use a SVAR model with four variables. I use monthly data for the time between 2007 and 2019. Even though my approach closely follows the one of Bekaert et al. (2013), this study is unique in so far as that I examine the period after 2007 and thus exclusively focus on monetary policy in the EMU. Further, I do not have any knowledge of studies analysing the asymmetry effects in Europe nor studying the possible spillover effects from the U.S. I also refrain from splitting up the implied volatility index in its components as this would exceed the extent of this thesis by far. I leave this up to further research.

Firstly, to proxy uncertainty I use the monthly volatility index on the national stock indices for the EMU, Germany and France. Particularly, I use the V2X, VDAX and VCAC for the individual markets, respectively.[21] It is crucial to keep in mind that those indices measure not only stock market uncertainty but also some degree of risk aversion. This could lead to biases that might have an effect on our results. However, it is a widely used tool in economic literature and I thus also follow this approach.[22]
Unfortunately, GIIPS countries do not have such a volatility index. Therefore I use the 90 day volatility of each index instead.[23] However, robustness test have shown that is a valid alternative. All time series data were taken from Bloomberg and are measured at the end of each month. Further, I follow Bloom (2009) and Bekaert et al. (2013) and take the logarithm of each time series.

Secondly, to simulate the shock in non-monetary policy measurements I use the monthly national target balances of each country as described in subsection 2.3.2. We again took the end of the month positions. Since all national target balances have to add up to zero, I obtain positive and negative values for some countries. We thus have to be careful when interpreting our response functions. Data on the national target balances are available on the ECB statistical data warehouse.

[21] The underlying stock indices are the DAX, CAC40 and EuroStoxx 50, respectively.

[22] Only few researchers such as Bekaert et al. (2013) split these indices in their individual components. For the sake of simplicity, I will refrain from doing this at this point.

[23] For Greece, Italy, Ireland, Portugal and Spain I use the ASE Index, the FTSE MIB, the ISEQ, the PSI20 and the IBEX, respectively.

Lastly, I implement several control variables. In order to control for cyclically or fluctuations in the economy I add the national level of industrial production as our third variable ((Bloom (2009), Bekaert et al. (2013)). Data for the individual countries were obtained from the OECD database, while an aggregate for the EMU can be found on Eurostat. For the sake of comparison, I transformed the data into an indexed time series, using January 2007 as the reference date. We then again took the natural logarithm of each series (Bernanke and Blinder (1992)). Moreover, since I want to study the effects on stock stock market uncertainty, I also need to control for natural stock market movements themselves. To do so I use monthly stock market log returns of the national stock indices as our fourth variable. The data were taken from Bloomberg.

Table 2
Variable Description The table shows and explains the labels and the description of the variables used for the SVAR model.

Label	Variable Description
IP	Level of Industrial Production: Natural logarithm of indexed time series, using January 2007 as the reference date to proxy business cycle fluctuations.
UMP	Unconventional Monetary Policy: Monthly national target balances of each country (end of the month positions).
VOL	Level of Volatility: Monthly volatility index on the national stock indices for the EMU (V2X), Germany (VDAX) and France (VCAC) and 90-day volatility levels for Greece, Ireland, Italy, Portugal and Spain.
RE	Stock market Returns: Monthly stock market log returns of the national stock indices.
FFR	Artificially created variable that combines the official FED short term rate for the period before 2009 and the Wu-Xia shadow federal funds rate for the period afterward.
MLR	Marginal Lending Rate: Marginal lending rate for the main refinancing operations (MROs).

4.2 SVAR Model

The model is similar to the example illustrated in equation (4.6). For each of the countries I am estimating a separate model. First, I define the endogenous vector as

$$\zeta_t = (IP_t, UMP_t, VOL_t, RE_t)' \tag{37}$$

where IP_t, UMP_t, VOL_t and RE_t denote the level of industrial production, unconventional monetary policy, uncertainty and stock market returns, respectively. The order of the variables has a crucial implication. It reflects our assumptions on the pace at which the individual indicators are reacting. Since stock market returns and uncertainty usually react relatively fast to economic shocks, I order them lower than industrial production and monetary policy. The two latter ones are commonly considered as slow moving (Bekaert et al. (2013), Bloom (2009)). To make assumptions regarding the contemporaneous relations between the endogenous variables I define our restrictions matrix A as

$$\begin{bmatrix} a_{1,1} & 0 & 0 & 0 \\ a_{2,1} & a_{2,2} & 0 & 0 \\ a_{3,1} & a_{3,2} & a_{3,3} & 0 \\ a_{4,1} & a_{4,2} & a_{4,3} & a_{4,4} \end{bmatrix}$$

The first row describes the relationship between the variable that is ordered first in ζ_t, namely business cycle, and the remaining variables. The coefficient $a_{1,1}$ describes the dynamics between the variable and itself. It thus can be assumed to be one. The same applies for all other diagonal elements ($a_{1,1}$, $a_{2,2}$, $a_{3,3}$, $a_{4,4}$). Further, I do not imply any contemporaneous relations between the business cycle and and the other variables. Bloom (2009) argues that companies usually make contracts several months or years in advance without certainly knowing how the economy will evolve in the future. Thus, macroeconomic shocks should not effect the business cycle instantaneously. The second row describes and restricts the variable that is ordered second, which is UMP_t. By trying to keep a tight rein on the economic fluctuations, the central bank wants to prevent an overheating as well as a recession in the economy. It thus makes sense to assume an contemporaneous relationship between UMP_t and IP_t. Since the ECB is more concerned about the price stability in the medium and long term run, it seems plausible to insinuate an instant relationship between UMP_t and VOL_t. In addition, I adopt some degree of market efficiency by assuming that every available information, especially when they are macroeconomic, are instantly reflect in the market price (Fama (1970)). This also explains the dynamics between our uncertainty variable and the macroeconomic variables. The reason why I set $a_{3,4}$ to zero is that implied volatilities are forward looking and therefore already incorporate today's stock price (Pennacchi (2008)). Since I do not use implied volatility indices for the GIIPS countries, this restriction might be faulty. Given the fact that we set six coefficients in matrix A equal to 0, the number of restrictions satisfy the restriction of having at least $n(n-1)/2$ restrictions. Using maximum likelihood, I can then estimate the model.

4.3 Spillover Effects

Figure 1 shows that the FED started significantly lowering its rate before 2010 reaching the ZLB in 2009, while the ECB lowered its official more gradually until its finally also reached the ZLB at the end of 2014. This can be partly explained by the heterogeneity of the EMU. While the FED deals with only one fiscal policy, the ECB has to take into account the consequences of several countries, each being in a different phase of the business cycle. We therefore use the monthly FED funds rate for the time period prior its reach the ZLB. For the time afterwards, I will use the so called *Federal Fund Shadow Rate* which was introduced by Wu and Xiah (2013). The idea behind the shadow rate is that unconventional monetary policy measurements do have an impact on the long term interest rates. From those long term rates I can then calculated the implied and unobserved short term rates. It can be seen as an artificially created interest rate that would have been in place if I allow interest rates to be negative (Lombardi and Zhu (2014)). Data on the Fed Funds Rate is publicly available for quite a long period but it is inadequate for the period where interest rates fall below the zero lower bound. The Shadow Fed Funds Rate data, however, is only accessible from January 2009 onward. Thus, it does not track our whole sample period, which is from 2007 to December 2019. For our empirical approach this means that for the period from June 2007 to April 2009 the monetary policy stance is defined as the actual Fed Funds Rate. Thereafter, when the Shadow Fed Funds Rate falls below the actual rate, I use the Shadow Rate as a measure for monetary policy. We obtained the Fed Funds Rate data from the Bloomberg database. The version of the Shadow Fed Funds Rate which is employed in our study was introduced by Wu and Xiah (2013) is publicly available on the website of the Fed Atlanta.

To assess the possible spillover effects from the FED, I simply substitute the UMP_t factor and rewrite the endogenous vector as

$$\zeta_t = (IP_t, FFR_t, VOL_t, RE_t)' \tag{38}$$

where FFR_t denotes the newly created variable that combines the official FED short term rate for the period before 2009 and the Wu-Xia shadow federal funds rate for the period afterwards. I do not change the restrictions in our matrix A since the above explained dynamics between the variables should not change if we change the instrument of the central bank.

4.4 Channel Examination

Lastly, I am going to examine through which channels the ECB affected stock market uncertainty the most. Outlined in subsection 2.3.2, the unconventional actions taken by the ECB can be categorized in three major programs. These include the direct purchases of government debt (the Securities Markets Program), the Outright Monetary Transactions under which the ECB partial commits itself to buy government debt and finally the Long-Term Refinancing Operations which describes 3-year loans given to banks. (Krishnamurthy et al. (2017)). I try to shed light on the question of which of these programs had the biggest effect on the stock market. Since empirical literature already proves that those programs led to in increase in stock prices in distressed and core countries (Krishnamurthy et al. (2017)), I mainly focus on the effect on uncertainty.

I will follow the common approaches in financial literature (Krishnamurthy et al. (2017)) and apply a standard event study to examine the effects. In particular, first, I construct two day changes of the volatility levels of the national stock indices. Due to the fact that the VDAX, VCAC and V2X do only contain monthly values I will also take the 90 day volatility for those indices. Afterwards I create three dummy variables, each for one program. The dummy for the SMP takes the value 1 on May 10, 2010 and August 7, 2011, the dummy for the OMT does so on July 26, 2012, August 2, 2012, and September 6, 2012 and the dummy for the LTRO for December 1, 2011 and December 8, 2011 (Krishnamurthy et al. (2017).

In a second step, I regress the changes in the volatility index against aggregate uncertainty and the dummy variables

$$\Delta VX_t = \alpha_{0,t} + \alpha_1 \Delta_{Agg,t} + \beta_0 SMP_t + \beta_1 OMT_t + \beta_2 LTRO_t + \varepsilon_t \tag{39}$$

This enables me to extract the individual effects of each program. One need to consider that this kind of approach assumes that changes in volatility are mainly driven by the monetary policy announcements on the respective dates. For this reason, I only took a few days to make sure that I solely include dates that are related to the announcements. Especially for the LTRO one needs to be cautious since announcements were revealed rather continuously than discrete (Krishnamurthy et al. (2017)). Since I only focus on the dates around the announcement day I can only measure the initial reaction to it but the full impact. This analysis is likely to underestimate the full effect each program has.

5 Results

This section reports on the results of the above described SVAR models. First, I will show how a shift in the monetary policy of the ECB to more unconventional instruments affects the stock market uncertainty in Germany, France, the GIIPS countries and the EMU itself. Afterwards, I will also analyze the autonomy of the monetary policy by examining possible spillover effects from the U.S. Lastly, I will try to shed light on the channels through which the ECB implemented their policy.

5.1 Unconventional Monetary Policy

The results are obtained from the our SVAR models which have been described above. In order to determine the appropriate lag order, I decided to use the Akaike information criterion (AIC). The calculated values of the criterion are displayed in table 3.

Table 3
Akaike Information Criterion Lag Selection: The table shows for each country the significant Akaike information criterion and the respective number of lags.

	GER	FRA	EMU	GRE	ITA	IRE	POR	ESP
Panel A: Unconventional Monetary Policy								
AIC	-1.291*	-2.363*	-5.175*	-1.969*	-1.878*	-0.289*	-4.382*	-2.500*
Number of lags	4	2	2	2	3	5	2	2
Panel B: Spillover Effects								
AIC	-10.625	-4.572	-5.478	-8.144	-10.601	-7.383	-9.765	-10.704
Number of lags	4	2	2	2	6	5	2	3
Panel C: Channel Examination								
AIC								
Number of lags								

As can be inferred from Panel A above, I will apply a lag order of two for France, Greece, Portugal, Spain and the economic and monetary European union. For Germany, Italy and Ireland I apply a lag order of four, three and five, respectively. We couch the main results in the form of impulse-response functions (IRFs). The graphical results can be found in figure 3. All lines are calculated by replicating 1000 bootstrap replications. This is much in line with the work of Bekaert et al. (2013). However, unlike Bekaert et al. (2013) who used 90 per cent confidence intervals, I widen the confidence bounds to 90 per cent. The lines represent the structuralized impulse-response functions who measure the impact of shocks in the monetary policy on stock market uncertainty for the respective domestic country for the subsequent 40 months. It is important to note that I simulate shocks in target balances. These shocks can be thus either positive or negative depending on the target balances of each country. For instance, Germany runs large positive balances and consequently experiences a positive shock. In contrast, most of the GIIPS countries run deficits on their balances and a shock is negative. Hence, the interpretation of the IRFs might be different among the countries.

Starting off with the non-peripheral countries, one can observe that a shock in monetary policy in Germany, which is equivalent to an increase in TARGET2 balances, reduces the uncertainty in the short and medium term. The reaction reaches its maximum of 0.023 after 3 months. However, the effect dies off relatively quickly and gets insignificant after 10 months. This implies that an increase in the national TARGET2 balances of the Bundesbank lessens the uncertainty by 2.3 per cent. Moving to France, the impulse response function seems quite different at first glance. Consequently, a shock in monetary policy initially decreases uncertainty during the first 4 months by around 2.5 per cent. Afterwards, uncertainty starts to gradually increase. The VCAC volatility index increase in the medium and long term to below but above 0.1 per cent. Surprisingly, this effect does not lose its significance over the horizon. These results are reflected in one of our main findings, namely that there is much heterogeneity with in the EMU regarding reactions to ECB policies. One possible explanation is given by Sinn et. al (2011) and Klepsch and Wollmershaeauser (2011). The papers show that the German and French euro are in imbalance with their productivity levels. Further, the compositions of their respective GDP's might differ substantially. The share of industrial production in the German GDP is almost 50 per cent higher as in France. The different effects in Germany and France are quite puzzling and needs to be examined by further research. The core question will be why ECB decisions transmit asynchronously to the EMU countries. The ECB council should take this into account when conducting or introducing new measurements.

Moving onward to the southern European countries, I obtain a pattern in the impulse response functions. Since all of the GIIPS countries were running negative target balances, an increasing response function above the horizontal axis represents a shrinking of uncertainty. Consequently, one can observe a rise in uncertainty in the short term after about four to five months. This short term effect reaches its maximum after around 3 months for Spain, Italy, Greece and Ireland respectively. The magnitude is different for each country with Italy showing the strongest magnitude of around 0.045. The short term movements are all significant. Only for Portugal an initial increase cannot be found. Rather, the volatility in Portugal instantly decreases reaching its maximum at around 2.5 per cent after five months. This effect is significant. After the initial reaction, the uncertainty in those countries started to shrink quite rapidly. While the mid and long term effect in Portugal and Spain gets insignificant after around 8 and 10 months, respectively, one can observe a significant reduction in uncertainty as a response to a one unit shock in the target balances in Greece, Italy and Ireland. At its maximum a negative shock in the target balances of Greece reduces the volatility level by around 0.04 after around 8 months. Italy experiences its highest decrease of uncertainty at around the same time as Greece even though it is with 0.017 lower. In contrast, the maximum reaction in Ireland is somewhat significant lower at only 0.008 after around 14 months.

Finishing off with the EMU, one might interpret the V2X reaction as a combination between the reactions of the VDAX and the VCAC. This is due to the fact that most companies that are listed in the V2X are either German or French based countries and thus also listed in the DAX or the CAC40. Overall, the EMU experiences a decrease in volatility in the medium and long term. However, the effect loses its significance already in the short run. The reason why the impact on the EMU as a aggregate is weaker than on individual countries might be the fact that the Eurozone additionally suffered from a a balance of payment crisis. Krugman (1979) shows that in order to solve such payment crisis, the central bank need to be aware that the credibility of its monetary policy is crucial. As a result, people might attached more weight to the decisions of the ECB when evaluating the future expectations.

The result, that declining implied volatility or variance levels can be persistent over time is a key finding for the ECB council and other policy makers. This could result in a permanent contraction of aggregate risk aversion which could lead to misallocation of capital and eventually end in financial bubbles (Bekaert et al. (2013)).

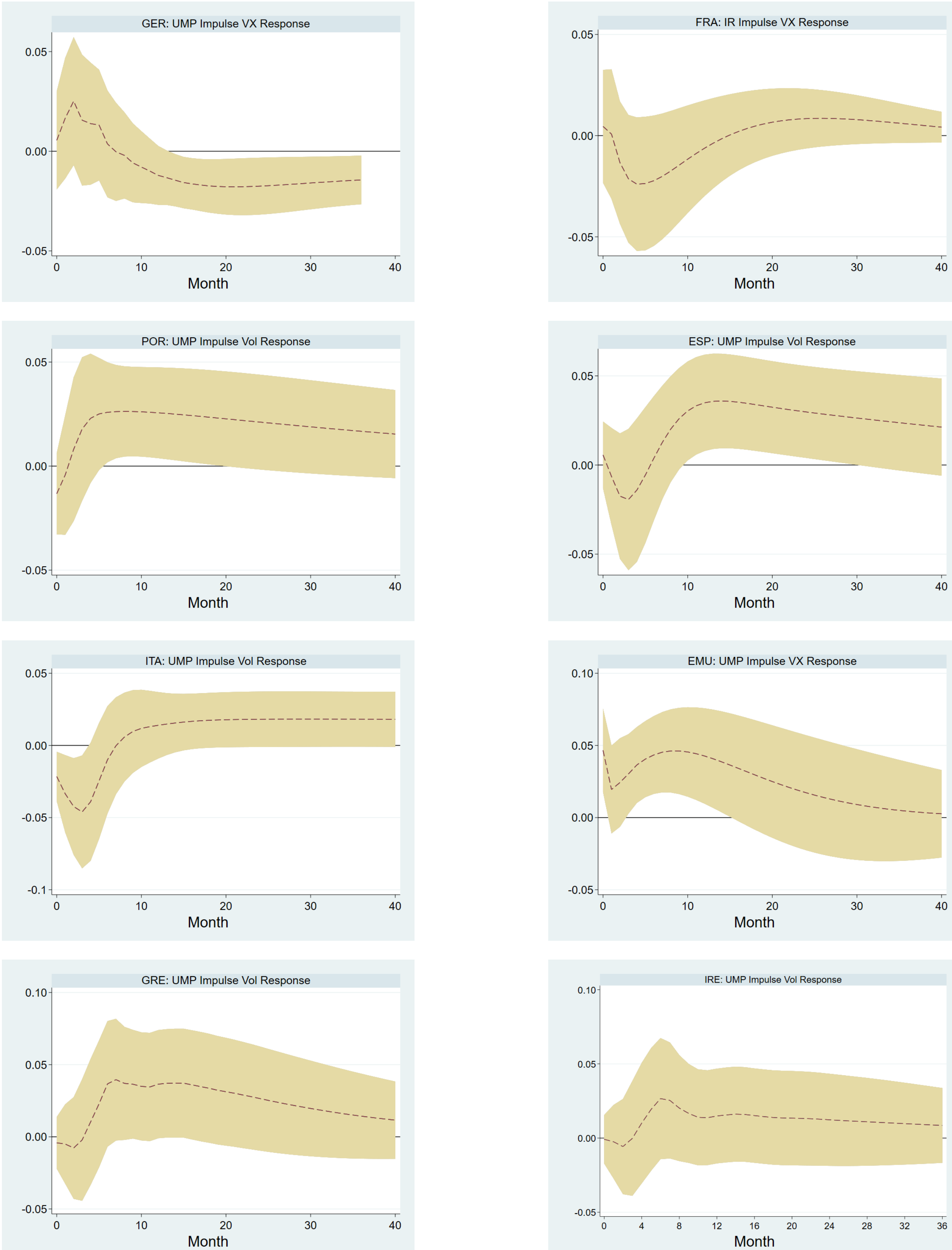

Figure 3: Structural-form impulse response functions (dashed lines) for the four-variable model. Impulse in national target balances and responses in uncertainty indicators. The results are shown for the subsequent 40 months. The area around the dashed lines represents 95% confidence intervals based on 1000 bootstrap replication. The sample period is from January 2002 until January 2019.

Similarly to Bekaert et al. (2013) I also examined the effect of changes in uncertainty on national production level since output levels influence the expectations on future inflation rates as it is shown above in equation (16). The results are displayed in figure 4.

Again starting off with the non-GIIPs countries and the EMU as an aggregate, one can observe that all short term effects are insignificant. This is as expected as business cycle indicator are usually more slow moving variables than for instance stock market variables (Wright (2012)). As a consequence, changes in the volatility or implied volatility should not impact industrial production instantly. The IRFs coincide with the results of Bloom (2009). In particular, a negative shock in volatility decreases the industrial output in Germany by around 10 per cent after 11 months. Its maximum reaches it after around six months with a reduction of close to 12 per cent. In contrast, the reaction in France is not as strong as in Germany. Here is the maximum decrease in output only at around 0.4 per cent after 12 months. This can be explained by the strong industry overweight that Germany has. According to the IMF, exports accounted for 41 per cent of the national output and industry made up almost a third of the country's GDP. Finally, it seems that the production overshoots for France and Germany. This phenomena was also found by Bloom (2009) who argues that many companies are located close to their hiring and investment thresholds. Positive shocks lead to an increase in labour workforce and investments while a negative shock has no effect. Hence, hiring and investment are locally convex in demand and productivity, respectively. The increased volatility of those two business conditions growth after a shock therefore leads to a medium-term rise in labor and capital (Bloom (2009)).

Further, analyzing the peripheral countries, one can see that the initial reaction is insignificant as well. The explanation of slow moving macro variables does also hold in Ireland and the southern part of Europe. Afterwards, industrial production shrinks in all of the countries. The effect is especially strong Spain, Italy and Ireland where the maximum reduction lies at above but close to 10 per cent. In contrast, the response functions reaches its maximum for Greece and Portugal at 0.6 percent and 0.4 per cent, respectively. A reasonable explanation for this could be that the export of those three countries are significantly higher than the exports of Greece and Portugal. Thus the economy of Spain, Ireland and Italy are much more depended of their exports than Greece and Portugal and uncertainty levels play a more important role. Thus, the policy makers need to account for the fact that a negative shock can drag down the output levels and thus have deflationary tendencies. However, since the IRFs become insignificant at some point, the conclusion should be interpreted with carefulness and not be seen as a advice.

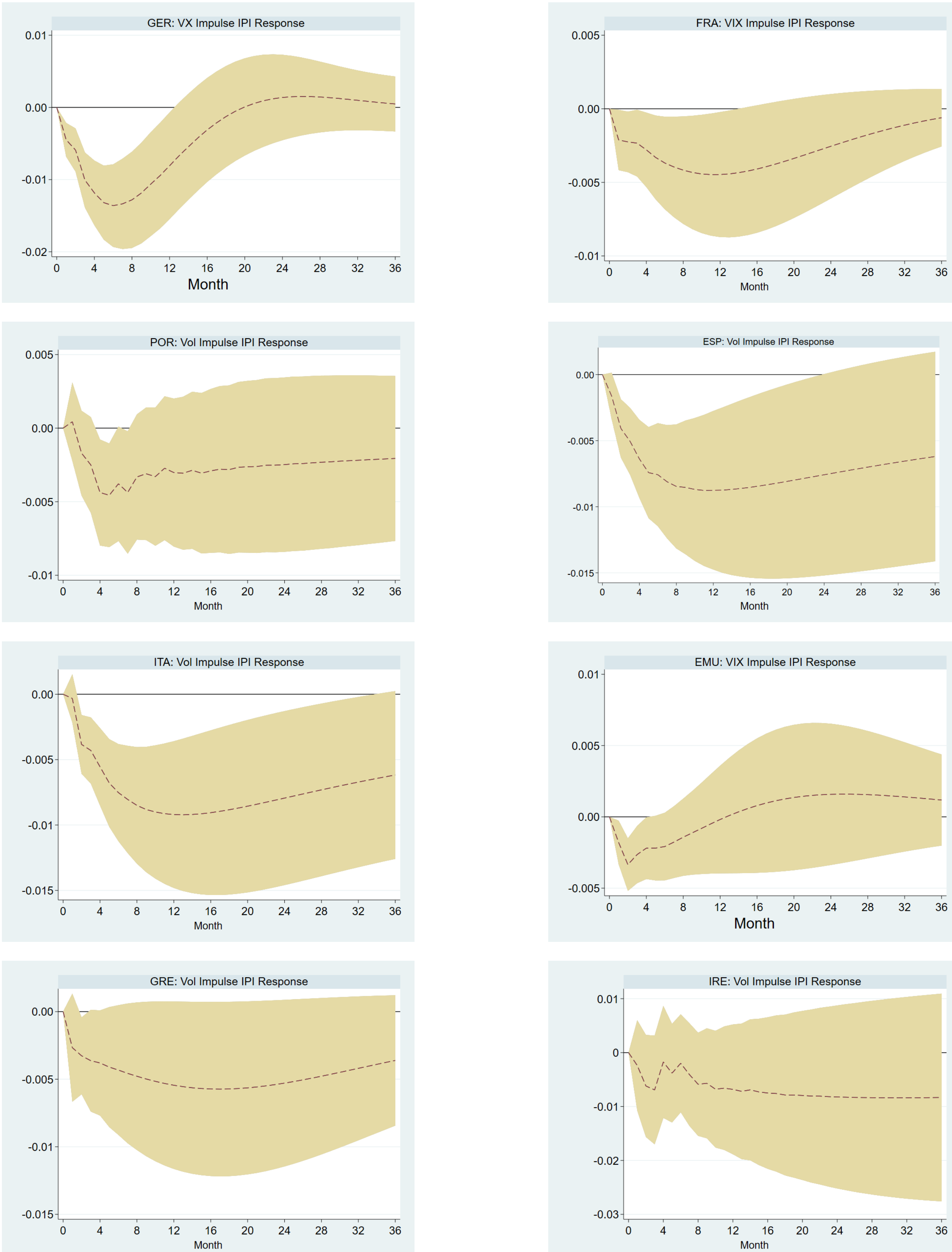

Figure 4: Structural-form impulse response functions (dashed lines) for the four-variable model. Impulse in uncertainty and response in production. The results are shown for the subsequent 40 months. The dashed lines represent 95% confidence intervals based on 1000 bootstrap replication (grey area). The sample period is from January 2002 until January 2019.

5.2 Spillover Effects

As already described above, empirical literature has found significant evidence that the monetary policy in the United States has an substantial effect on monetary and macroeconomic variables in the other countries (Wright (2012) and Neely (2010)). Further, figure 1 has shown that the path of interest rates determined my the ECB follows the path of rate set by the FED with a certain lag. Consequently, we make the hypothesis that U.S monetary policy directly affects and partial determines the official interest rates in the EMU. To make sure that this causality is only unidirectional and not bidirectional (i.e. ECB rates also affect FED rates or only one way I apply a simple Granger causality test. The results are shown in table 4 below.

Table 4
Granger Causality Wald Tests: The table shows the test results for the Granger causality tests. MLR and FFR represent the marginal lending rate for the main refinancing operations and the FED Funds Rate, respectively. The causality is tested for the period between January, 2000 and February 2019.

H_o	MLR does not cause FFR		FFR does not cause MLR	
Test Statistics	χ^2	p-value	χ^2	p-vlaue
Lag Structure (VAR order)				
1(2)	2.5322	0.282	45.42	0.00
2(3)	2.9464	0.567	35.16	0.00
3(4)	11.326	0.079	42.37	0.00

From the test results, it can be inferred that the marginal lending rate does not Granger cause the FED Funds rate at a 90% level (p>0.05). However, the hypothesis that the Fed Funds rate does Granger cause the marginal lending rate at a 90% level (p<0.1) is also accepted. As a result, I will only examine possible spillover effects from the U.S to the EMU and not the other way around. To do so, I follow the approach described in subsection 4.3 and substitute UMP_t with $USIR_t$ in equation (37) where $USIR_t$ represents the combination of the Fed Funds rate and the shadow rate. I imply a shock in this variable and obtain the response function of the implied volatility or actual volatility levels of the national indices. The IRFs are shown in figure 5. I imply a negative shock, meaning a decrease in the interest rate.

For Germany and France I find, that a drop in the U.S interest rate lowers overall uncertainty in the country. While for France, the short term effect if found to be insignificant, the spillover effect is found to be persistent and significant for both countries in the long run. The effect for the GIIPS countries exhibit a slightly different pattern. The countries volatilities initially begin to rise in the short term. However, after an insignificant mid term correction, the volatility is like in Germany or France significantly lowered in the long term trend. These findings are consistent with the IRFs shown in figure 4 to the extent that laxer monetary policy, which can be implemented to a negative shock in interest rates or an increase in target balances, lower overall uncertainty in the long run for most countries in the EMU. Bakeart et al. (2013) show that this effect is also to be found in the United States.

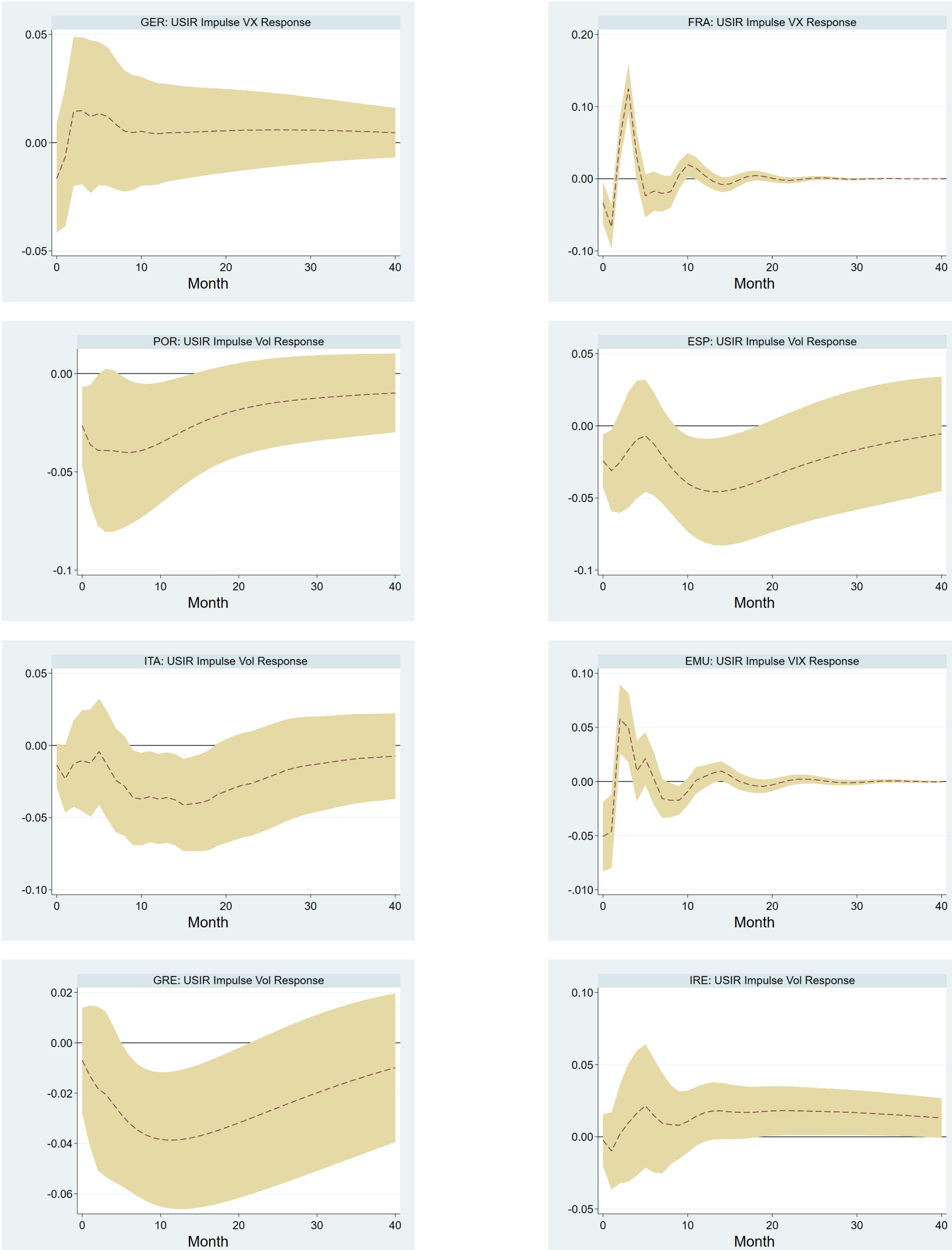

Figure 5: Structural-form impulse response functions (dashed lines) for the four-variable model. Impulse in U.S interest rates and response in uncertainty indicators. The results are shown for the subsequent 40 months. The area around the dashed lines represents 95 per cent confidence intervals based on 1000 bootstrap replication. The sample period is from January 2002 until January 2019.

5.3 Channels for Policy Impact

Lastly, I dissect unconventional monetary policy into SMP, OMT and LTROs. This enables us to closely examine the individual channels through which the ECB implemented its non-monetary operations. As explained in section 4 I regress 5-day changes in 90-day volatility on dummy variables.

Table 5 reports 5-day changes in historical volatility levels around the SMP, OMT, and LTRO event dates. Volatility levels fall dramatically in all countries for the SMP program. This coincides with the findings of Krishnamurthy et al. (2013) who find that SMP significantly lowers the bond yields within all GIIPS countries. Similarly, I also find that reactions in the non-peripheral countries are among the strongest in our sample. Volatility levels in Spain show a significant drop of almost 21 per cent followed by Italy with 18.5 per cent. The lowest reaction can be found in Portugal and Greece. It stands out that the first event date within the SMP program, May 10, 2010. This finding suggests that the expansion of already existing programs has a significantly lower effect on stock market variables than the announcement of new programs.

Table 5
Policy impact of individual channels. The table reports on the impact of unconventional monetary policies on stock market uncertainty in member countries of the EMU.

		Germany	France	Greece	Ireland	Italy	Portugal	Spain	EMU
Policy	Ann. date								
SMP	May 10, 2010	-0.059***	-0.115***	-0.063***	-0.084***	-0.135***	-0.107***	-0.167***	-0.122***
	Aug 7, 2011	-0.070***	-0.064***	-0.029***	-0.062***	-0.050***	0.018***	-0.041***	-0.060***
	Total	-0.129***	-0.179***	-0.092***	-0.146***	-0.185***	-0.089***	-0.208***	-0.182***
OMT	Jul 26, 2012	-0.020***	-0.024***	-0.010***	-0.008***	-0.041***	-0.029***	-0.056***	-0.030***
	Aug 2, 2012	-0.010***	-0.011***	0.045***	0.012***	-0.032***	-0.006***	-0.040***	-0.02***
	Sep 6, 2012	-0.008***	-0.008***	0.036***	-0.001	0.002***	0.000	-0.008***	-0.009***
	Total	-0.038***	-0.043***	0.071***	0.003**	-0.071***	-0.035***	-0.104***	-0.059***
3-year LTROs	Dec 1, 2011	0.020***	0.016***	0.050***	0.010*	0.026***	0.011*	0.023***	0.023***
	Dec 8, 2011	0.017***	0.018***	0.005***	0.016*	0.009***	0.015*	0.022***	0.020***
	Total	0.037***	0.034***	0.055***	0.026*	0.035***	0.026*	0.045***	0.043***

Furthermore, I find that the effect of the OMT program shows a higher degree of heterogeneity among countries than the SMP program did. Spain exhibits again the highest reaction with a drop of more than 10 per cent in historical volatility. However, the volatility levels in three of the four remaining GIIPS countries show a positive reaction to a loosening monetary policy. Greece, Ireland and Italy all show positive and significant coefficients, which are noticeably above the EMU average of about minus 6 per cent. Thus, OMT as well as SMP both lead to overall reductions of uncertainty within in the EMU, even though the effect might differ across countries

Finally, analysing the effect of the 3-year LTRO program, I obtain quite different results. For all countries in our sample, I find that uncertainty in each country rises around the announcement date of the program. In particular, the changes in volatility in Ireland and Spain are not significantly different from zero. In Greece and Portugal however, one can observe a significant positive relationship. Krishnamurthy et al. (2013) who find also a positive impact on bond yields argue that Greece and Portugal showed generally high volatility levels around those dates which might outweigh the LTRO effect and thus distort results.

6 Conclusion

Analyzing unconventional monetary policy in EMU after the financial crisis of 2007, I show how the ECB tried to adjust the path of inflation towards its desired rate. Implementing such non standard measurements, however, does not only have an impact on the inflation but also on macroeconomic and financial market related variables. Using structural vector autoregressive models, I examine how the ECB affects stock market uncertainty and industrial output once it reached the zero lower bound. In particular, I first split the Euro area up into GIIPS and non-GIIPS countries which include France and Germany. This allows us to take the heterogeneity of the EMU into account. Secondly, I then simulate shocks in monetary policy proposing national target balances as a proxy. This approach has not been used before in financial literature so far. Since target balances vary across countries, I think that this method captures heterogeneity within the EMU the best. Subsequently, I also check for possible spillover effects from the FED policy in the U.S given the fact that ECB policy followed the U.S with a lag of approximately four years. To proxy the non standard policy measurement of the FED I apply a combined rate of the official funds rate and a shadow rate proposed by Wu and Xiah (2013). Finally, I dissect unconventional policies of the ECB into its three main components: SMP, OMT and LTRO. Using an event study approach I aim to identify what primarily drives uncertainty.

In general, this thesis find that unconventional monetary policy lowers stock market uncertainty within the EMU. This coincides with the findings of Wright (2012) and Bekaert et al. (2013) who examined this relationship for the U.S. However, due to the heterogeneity within the EMU, I also show that non-standard policy measurement transmit asynchronously to the member countries of the euro area. In particular, for most of the GIIPS countries I find that uncertainty decreases in the mid and long term after an initial increase within the first four months. While the effect in Portugal and Spain dies off early, reductions in uncertainty in Greece, Italy and Ireland remain significant in the long term. For Germany I find that uncertainty is only lowered during the first 10 months reaching a maximum after 3 months. In contrast, France experiences an initial increase within the first four months. However, The VCAC volatility index increase in the medium and long term to below but above 0.1 per cent. Surprisingly, this effect does not lose its significance over the horizon. Sinn et. al (2011) and Klepsch and Wollmershäuser (2011) argue that substantial differences in share of industrial production of the GDP in France and Germany may explain this imbalance. The result, that declining implied volatility or variance levels can be persistent over time is a key finding for the ECB council and other policy makers. This could result in a permanent contraction of aggregate risk aversion which could lead to misallocation of capital and eventually end in financial bubbles (Bekaert et al. (2013)). Additionally, I provide further evidence for spillover effects from the policy of the FED on to the euro area, as it shown by Neely (2010) and Wright (2012).

Secondly, I examined how changes in uncertainty affect national production level since output levels influence the expectations on future inflation rates. For non-peripheral countries one can observe that all short term effects are insignificant. This is as expected as business cycle indicator are usually more slow moving variables than for instance stock market variables (Wright (2012)). Afterwards, one observes reductions in industrial output in Germany and France in the medium term. Bloom (2009) shows that the magnitude is partially driven by the investment and hiring threshold of the companies. Furthermore, reductions in industrial output are also present in southern European countries. However, the main driver for those countries is the level of exports. Countries that have higher exports depend operate in a more international environment and thus rely more on higher certainty levels in other countries.

Finally, I provide evidence on the channels through which the ECB tries to implement its non-standard measurements. This is in particular important as I can examine the individual effects in each country. Similar to the findings of Krishnamurthy et al. (2013), I show that the launch of the SMP program dramatically lowers volatility levels in all countries in our sample. The reaction is much more pronounced among the GIIPS countries than among the non peripheral countries. Furthermore, I find that the effect of the OMT program shows a higher degree of heterogeneity among the countries. Uncertainty around the event dates of OMT decreases in five countries in our sample while it rises in Italy, Greece and Ireland. This is consistent with the findings of Krishnamurthy et al. (2013). In addition, I provide evidence that that the expansion of already existing programs has a significantly lower effect on stock market variables than the announcement of new programs. Lastly, our results indicate that the launch of the LTRO program leads to increase in volatility in almost all countries. Krishnamurthy et al. (2013) argue that some of the GIIPS countries showed generally high volatility levels around those dates which might outweigh the LTRO effect and thus distort results. One need to consider that this kind of approach assumes that changes in volatility are mainly driven by the monetary policy announcements on the respective dates. For this reason, I only took a few days to make sure that one solely include dates that are related to the announcements. Especially for the LTRO one need to be cautious since announcements were revealed rather continuously than discrete (Krishnamurthy et al. (2017)). Since

I only focus on the dates around the announcement I I only measure the initial reaction to it but the full impact. Our analysis is likely to underestimate the full effect each program has.

The findings provided above are likely to have crucial implications for the analysis and potential suggestions on future monetary policy actions. It is important to get a better understanding of the heterogeneity within the EMU and the different effects monetary policy has on individual countries to assess whether the ECB can effectively engage in the solution of the current crisis. Further, in respect of the debate on whether QE increases misallocation of capital and pushes asset prices above their fundamental values. Lower uncertainty supports the hypothesis that investors looses their risk aversion and might misallocate their capital leading to a distortion of asset prices. Consequently, further research should focus on the relationship between macroeconomic policies and uncertainty.

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