THE IMPACT OF THE EUROPEAN CENTRAL BANK'S NON-STANDARD MEASURES ON STOCK PRICES OF BANKS

Lappeenranta–Lahti University of Technology LUT

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Examiner: Associate Professor, Mika Vanhala

ABSTRACT

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The impact of the European Central Bank's non-standard measures on stock prices of banks

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Keywords: European Central Bank, unconventional monetary policy, monetary policy surprises, stock market

The aim of the study is to examine if unexpected unconventional monetary policy measures have an impact on stock prices of banks in Europe during 2009-2019. The monetary policy surprises are calculated as changes in spread of Italian and German 10-year government bond yields. The impact of policy measures is estimated with linear regression analysis.

According to the regression analysis monetary policy surprises have a statistically significant impact on stock prices of banks. When the policy measures are looser than what the stock market has anticipated the stock prices increase and when the measures are tighter than anticipated the stock prices fall.

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Tutkimuksen tarkoituksena on selvittää onko odottamattomilla epätavanomaisilla rahapolitiikkakeinoilla vaikutusta pankkien osakehintoihin Euroopassa vuosina 2009-2019. Rahapolitiikkayllätykset lasketaan Italian ja Saksan 10 vuoden valtionlainojen korkojen välisestä erojen muutoksesta. Politiikkatoimien vaikutusta estimoidaan lineaarisella regressioanalyysilla.

Regressioanalyysin perusteella rahapolitiikkayllätyksillä on tilastollisesti merkittävä vaikutus pankkien osakehintoihin. Kun politiikkatoimet ovat löyhempiä kuin osakemarkkinat ovat olettaneet, osakehinnat nousevat. Kun taas tiukemmat politiikkatoimet saavat osakehinnat laskemaan.

Table of contents

Appendices

Figures

Tables

1 Introduction

In the late summer 2008, a financial crisis developed in the US after the amount of mortgage delinquencies started to rise in 2007 which led to bankruptcies of mortgage lenders (Kotz 2009, 305). Pohjola (2019, 275) explains in more detail that mortgage lenders issued subprime loans, converted them into liquid securities, and sold the securities to other financial institutions. According to Mayer, Pence and Sherlund (2009, 27) subprime loans are loans issued to borrowers who are involved with a higher default risk than normally for example due to a small amount of savings available or a poor credit history. The crisis was a result of the banks' excessive risk taking while issuing the subprime mortgages. Prices of houses started to drop in 2006 due to an increase in interest rates and caused credit losses to lenders when subprime borrowers could not pay back their loans. The securitised subprime mortgages lost their value due to the delinquencies. Banks became afraid of lending funds to each other since they were uncertain which banks had these securities in their balance sheet and to what extent. Decreased trust among banks caused risk premia of lending between banks to rise and therefore banks reduced lending to each other. Decreased lending caused the banking system to malfunction which posed a severe threat to the whole economy. (Pohjola 2019, 109, 275) As Ureche-Rangau and Burietz (2013, 35) explain, the financial markets have become globalized and integrated which caused the financial crisis to spread from the US through the malfunctioning banking system globally, including Europe. Consequently, the level of exports and investments decreased, and the Euro area fell into a great recession as well. Central banks interfered the malfunctioning banking system by increasing their lending to banks at low interest rates to secure liquidity of banks. In other words, the central banks started to partly carry the risks of the banks and the risk premia of the banks started to decrease and the crisis tranquilised. The Euro countries recovered at different pace from the crisis, but some countries experienced a double recession when a debt and confidence crisis emerged in Europe in the autumn 2011, due to Greece being on the verge of insolvency. The European banks became increasingly hesitant to lend funds to each other in the fear of default risks as the government bonds of Greece lost their value and banks did not know which banks had these bonds in their balance sheets. As a result, the risk premia in the financial market increased again. (Euro & Talous 2018, 46, Pohjola 2019, 110)

The debt and confidence crisis caused the whole Euro system to be in danger of collapsing (Pohjola 2019, 110).

The European Central Bank (the ECB) tried to recover the Euro area from the crisis via its monetary policy. The ECB's main instrument for steering economy was to set three policy rates: main refinancing operations rate (MRO), rate on the deposit facility, and rate on the marginal lending facility (European Central Bank 2022b). The policy rates are explained in more detail in subchapter 2.1. Apergis (2019, 372) explains that, as the ECB started to decrease the rates closer to zero to promote recovery of the economy, the existing monetary policy tools lost their effectiveness. The crises therefore forced the ECB to find new techniques to exercise monetary policy and to help the banking system and the economy to recover because the standard measures were inefficient for reaching the main objective of the ECB, price stability. The ECB tried to revive the financial market by offering commercial banks loans with low interest rates, asset purchases, and forward guidance on policy decisions, so called non-standard or unconventional measures. (Afonso & Sousa-Leite 2020, 151, Albertazzi, Becker & Boucinha 2021, 1) This thesis studies what kind of impact these non-standard monetary policy measures of the ECB have on the stock prices of European banks.

According to the views of Kontonikas and Kostakis (2013, 1038-1039) and Apergis (2019, 372) understanding the impact of non-standard measures of monetary policy is important because it gives information to authorities and policymakers on how their decisions affect the economy and markets. Also, Rogers, Scotti and Wright (2014, 753) agree with the importance of the information to these parties. Dedola, Georgiadis, Gräb, and Mehl (2021, 490-491) adds that if crises arise in the future likely the ECB will continue using non-standard measures to practice monetary policy. Then the information will be crucial for forecasting the influences of their decisions. On the other hand, as Kontonikas et al. (2013, 1039) further explain, the information is helpful for investors when they analyse their investments, construct portfolios, and make other investment-related decisions.

Previous studies have been conducted to investigate the effects of standard measures, particularly the impact of increasing and decreasing the main refinancing operations interest rate of central banks on stock prices and stock indices. For example, Hussain (2011, 753) has found out that unexpected change in the policy rate of the European Central bank and the Bank of England has a significant impact on stock prices in Germany, Switzerland, France, and Britain. Haitsma, Unalmis and de Haan (2016, 102) came into the same conclusion when studying the policy rate of the ECB and the stock prices in Europe. Similar results were gathered by Kontonikas, MacDonald and Saggu (2013, 4025-4026) and Unalmis and Unalmis (2015, 1-5) with the Federal Reserve's unexpected change in interest rate and its impact on the US stock market. Studies related to the effects of using non-standard measures of monetary policy have been published by Rogers et al. (2014, 787-788), and Fiordelisi, Galloppo and Ricci (2014, 49-51). Rogers et al. (2014, 787-788) studied the impact of unconventional monetary policy of central banks in the US, the Euro area, Britain, and Japan. They found out that in the US, in the Euro area, and in Britain unexpected loosening of the policy increases stock prices of the domestic market and tightening policy in turn decreases the prices. However, in Japan the impact was neglectable. Fiordelisi et al. (2014, 49-51) found out that non-standard measures have a stronger impact on stock prices than changes in the main refinancing operations rate when they studied the Euro area, Britain, Switzerland, the US, and Japan. Rarely the studies related to the topic concentrate on researching the impact of the monetary policy on different sectors of economy such as the banking sector. The aim of the thesis is to study how the non-standard measures of the ECB's monetary policy affect the stock prices. The focus is on stock market in Europe and more particularly the thesis concentrates on listed companies in the banking sector. The main research question is as follows:

What is the overall impact of the European Central Bank's non-standard measures on returns of banks in the European stock market?

The following sub questions are formed to guide answering the main research question:

1. *What are the non-standard measures?*
2. *What are the impacts of the non-standard measures on stock markets?*

3. *How can the impact of non-standard measures be measured?*

The companies included in the research are limited to listed European banks. The financial sector could be researched more deeply for example by including insurance companies and other financial service companies to the study. Only the banks are considered in the thesis because the extent of the study narrow. Europe as a geographical limitation is chosen because it is predictable that the effects of the ECB's policy decisions are the strongest in the European market. The focus of the monetary policy is on non-standard measures because they have been in use since the financial crisis hit until today and studying them is quite new and more relevant compared to the standard measures that have been used earlier. The data collection period is from the beginning of 2009 until the end of 2019. The beginning of the financial crisis is not included in the time period to exclude the first influences of the crisis. Also, the impact of the corona pandemic is excluded from the results by limiting the time period to the year 2019.

Next, chapter 2 further discusses what is monetary policy, how it is used to steer development of the economy, how the policy is transmitted to the economy, and what monetary policy measures the European Central Bank has adopted. Chapter 3 presents the theoretical framework of the study, explains the ideologies behind efficient markets and random walk model, and how unexpected monetary policy actions may be measured. Chapter 4 focuses on explaining two theories relevant to the study. It explains money transmission of expansionary monetary policy through quantity theory of money and liquidity preference theory. Lastly the chapter summarises the main points of chapters 2-4. The study method, variables, and data are described in chapter 5. The results of the study and validity and reliability of the study are discussed in chapter 6. The results are further analysed and discussed in chapter 7. The chapter also discusses the contribution and limitations of the study and offers ideas for further investigation related to the topic of the thesis.

2 Monetary policy

This chapter introduces monetary policy, especially in the Euro area, and explains the transmission process of the policy in economy. Also, it discusses how the policy is exercised in practice and which tools the European Central Bank uses to reach its policy objectives.

2.1 Monetary policy and its transmission process

Central banks practice monetary policy. Monetary policy decisions affect the cost of money and how well money is available in an economy. In Europe, European Union has its own central bank, the European Central Bank (the ECB). The most important objective of the monetary policy is to ensure price stability in an economy. The current goal of the ECB for price stability is "to keep inflation at 2 % over medium term". (European Central Bank 2022f) During the period that is in the scope of this study the goal has been slightly different: the inflation rate is aimed to be near but slightly below 2 % at medium term as Freystätter (2016, 418) states. The primary instrument for keeping prices stable is by setting three key interest rates. The rates are main refinancing operations rate (MRO), rate on the deposit facility, and rate on the marginal lending facility. MRO rate means a rate at which the ECB lends funds to banks against collateral weekly. Rate on the deposit facility is lower than MRO and banks may deposit funds to the ECB overnight with the rate. On the contrary, the rate on the marginal lending facility is higher than the MRO rate and banks may borrow funds from the ECB with it overnight. (European Central Bank 2022b) The policy rates affect the price of finance. The development of the price furthermore influences development of macroeconomy. (Bank of Finland 2022b) Before further explaining what measures the ECB may take the transmission mechanism of the monetary policy is discussed.

Monetary policy decisions are transmitted to an economy through various channels. One absolute presentation of the channels does not exist. For example, Mishkin (1995, 4) and Angeloni & Ehrmann (2003, 472) recognize four channels of monetary policy transmission mechanism through which monetary policy affects aggregate demand of money. The

channels are the bank lending channel, the interest rate channel, the asset market channel, and the exchange rate channel. According to Bernanke and Gertler (1995, 29), through the bank lending channel, monetary policy influences supply of loans to businesses and consumers. Mishkin (1995, 4-5, 7-8) adds that loans increase firms' balance sheets and increase riskiness of the firms. He also states that the interest rate channel functions through short interest rates that have a positive correlation with long-term interest rates. Changes in the rates affect the demand of investments for businesses and consumers because higher interest rates increase the cost of capital. Angeloni et al. (2003, 488) explain that through the asset market channel (also called as stock market channel) the monetary policy actions influence stock prices which in turn affect firms' investment decisions and the wealth of consumers. Angeloni et al. (2003, 473) and Mishkin (1995, 5) agree that through the exchange rate channel monetary policy affects exchange rates and furthermore the domestic economy.

The European Central Bank (2022e) describes a more detailed chart of the main transmission channels (shown in Figure 1). According to the chart, when the ECB steers key interest rates it affects money market interest rates i.e., the rates at which banks borrow money from the ECB. Also, expectations of upcoming policy rates have an impact on the market rates and ultimately on the economy. Furthermore, changes in the policy rates affect the rate at which banks lend money to businesses and consumers, asset prices, and exchange rates. Changes in lending and asset prices affect the available funds businesses and consumers have for investments and consumption which in turn has an impact on aggregate demand and prices of goods and services. Mishkin (1995, 6) explains that increasing the policy rates causes bonds to become attractive and, therefore the demand for stocks decreases. Higher demand for bonds means lower demand for stocks and simultaneously bond prices increase and the prices of less favourable stocks will decrease. Mishkin (1995, 5) also explains that exchange rate affects import and export prices. For example, if euro is depreciated against dollar imported goods from the United States become more expensive for consumers and businesses in euro countries.

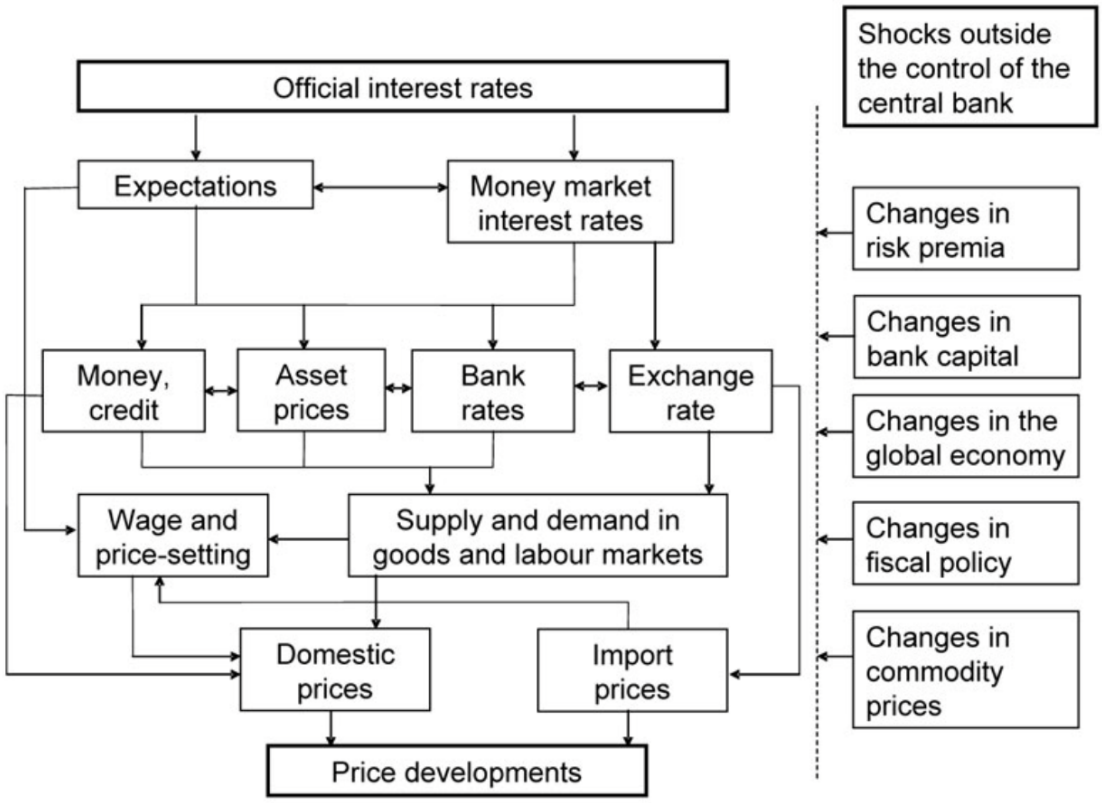

Figure 1. Transmission mechanism of monetary policy (European Central Bank 2022e).

Fratzscher, Lo Duca & Straub (2016, 37) state that the magnitude of the impact of monetary policy is hard to predict. Monetary policy is not exercised in a void but in the economic environment where shocks that the ECB cannot control may occur. In addition to the ECB's presentation of the transmission process, Apergis (2019, 373) and Mishkin (2015, 652-661) suggest that an expectations channel exists which supports the impact of monetary policy decisions on asset prices and the real economy. The expectations of economy's agents, for example investors and businesses, depend on the credibility of the central bank and the beliefs the agents have on the future actions of the central bank. Expectations shape the investment and spending decisions in the economy and therefore affect the development of the economy.

Central banks may alter monetary policy actions based on the current economic situation. According to Bernanke et al. (1995, 29-30), tight monetary policy causes four responses to an economy. Firstly, to exercise tight monetary policy central banks increase their policy rates. The rise in the rates causes real prices and GDP (gross-domestic product) to decline. Secondly, final demand falls which also causes production level to fall. Thirdly, the steepest and the most immediate decline in final demand occurs in consumer goods. Lastly, inflation and lower demand create an unfavourable environment for businesses to make investments and therefore, businesses try to avoid investments. Additionally, Ülke and Berument (2016, 353) explain that tight monetary policy causes banks to raise the interest rate levels and therefore the demand for loans decreases. On the contrary, the effects of loose monetary policy are opposite to the tight policy. According to Borio, Gambacorta & Hofmann (2017, 48-49) loose monetary policy means that the central banks lower the policy rates and use expansionary policy measures to support development of an economy. The lower policy rates decrease the money market interest rates and ultimately also the rates of longer maturity assets. From another perspective as Segev (2020, 1-2) explains, the loose policy leads banks to increase their tolerance of risk which results in a decrease of risk premia and lending standards decrease which in turn make borrowing funds from banks more favourable to businesses and households. Next sub chapter introduces the measures that are used to cause these influences in the economy.

2.2 Standard versus non-standard measures of monetary policy

Before the global financial crisis hit, the ECB used standard monetary policy measures (conventional monetary policy) to steer the development of economy as described in the previous subchapter 2.1. During the crisis, the transmission of the standard measures became ineffective and therefore the ECB required more tools for maintaining price stability and recovering the economy. The measures are called non-standard measures (unconventional monetary policy). This subchapter explains the policy measures the ECB uses, focusing mainly on the non-standard measures, and answers to the first sub question of the study *"What are the non-standard measures?"*.

Standard measures

Mankiw and Taylor (2014, 571) state that conventional monetary policy includes three policy tools: open market operations, standing facilities and minimum reserve requirement. They explain that the ECB conducts open market operations when it wants to influence the supply of money in the economy. If the objective is to increase the supply of money and furthermore increase the inflation rate, the ECB may create funds and buy bonds from the public from the bond market. On the contrary, the ECB may sell bonds it owns to the public and the money supply will decrease. According to Bank of Finland (2022a), standing facilities are used for changing the liquidity level in the banking system. It consists of marginal lending facility and deposit facility. Banks may borrow funds from the ECB against collateral overnight with the rate on the marginal lending facility and they may deposit funds to the ECB overnight with the rate on the deposit facility. Mankiw et al. (2014, 573) describe minimum reserve requirement to mean the ECB's "regulations on the minimum level of reserves that banks must hold against deposits". The reserve requirements help keep the money market stable by preventing commercial banks to go bankruptcy in case the defaults of their clients increase.

Non-standard measures

After the financial crisis started in 2008, the economy required loose monetary policy to recover and therefore the ECB had to lower its policy rates according to its monetary policy principles. When the crisis escalated, the ECB lowered its MRO rate to zero. (Laine 2019, 2900, Arteta, Kose, Stocker & Taskin 2018, 9) Laine (2019, 2900) and Apergis (2019, 372) explain that at the so called zero lower bound (ZLB) the conventional monetary policy becomes ineffective. During the crisis the financial systems became malfunctioning and consequently the monetary policy actions were not transmitted to the economy properly through the transmission mechanism. Therefore, the ECB was forced to find alternative measures to steer the development of the economy. (European Central Bank 2022e) Fiordelisi, Galloppo and Ricci (2014, 49) further explain that the goal of using the new policy techniques was to ensure monetary stability of the economy and to re-stabilise the financial systems. The European Central Bank (2022b) offers an answer to the first sub question of thesis: the non-standard measures of monetary policy include negative interest rates, targeted

longer-term refinancing operations (TLTROs), asset purchase programmes, and forward guidance. These measures are explained in more detail after discussing the transmission channels of the non-standard measures.

Transmission channels of non-standard measures

According to Praet (2016) and Freystätter (2016, 420) the non-standard measures have three primary channels through which their impacts are transmitted to the economy. The channels are direct pass-through channel, portfolio rebalancing channel, and signalling channel. Freystätter (2016, 420) explains that via the direct pass-through channel, the so-called credit easing policy tools (TLTROs and asset purchase programme) lower the banks' costs of finance which is further reflected on the macroeconomy as lower interest rates of lending and more favourable terms of borrowing funds from banks. Impacts of asset purchase programmes on stock prices are partly transmitted via the portfolio rebalancing channel. Fratzscher et al. (2016, 42) add that asset purchases by the ECB causes investors to flee from the market segments where the ECB has targeted the asset purchases and investors will reallocate their funds to other asset substitutes and thus rebalance their portfolios. Also, other monetary policy actions that affect risk premia and returns of assets cause portfolio rebalancing in the markets. Gambetti and Musso (2020, 3) explain that signalling channel transmits the impact of monetary policy decisions effectively because the monetary policy actions that are in place for a long period of time signal commitment of the ECB to achieve its objectives and signalling the timeline of the actions calms markets. The signalling channel functions like forward guidance which is used to communicate the policy stance of the ECB. According to Fratzscher et al. (2016, 42) and Dedola et al. (2021, 491), for instance, part of the effects of asset purchase programmes are transmitted to the economy via the signalling channel. Next, the four non-standard measures are explained further.

Negative interest rates

Kerola and Koskinen (2019, 46-47) state that the ECB introduced negative interest rates on the deposit facility in June 2014. The ECB charges banks for having excess reserves with setting negative interest rates on the deposit facility. Arteta et al. (2018, 8) refer to the

technique as negative interest rate policy (NIRP). Kerola et al. (2019, 46-48) explain that in practice, NIRP means that when banks deposit funds to their central bank accounts overnight, next day the amount on the account will be less than the amount deposited. The negative interest rate policy transmits to the economy primarily through the bank lending channel. Arteta et al. (2018, 8) and Freystätter (2016, 424) add that NIRP encourages banks to find more profitable investment options than keeping excess reserves in the central bank. The banks may increase lending money to other banks that need more liquidity, and they may also issue more loans to businesses and consumers. Freystätter (2016, 424) further explains that instead of lending money, banks may also choose to purchase securities with higher maturity and risk. Via the bank lending and portfolio rebalancing channels the negative rate on the deposit facility decreases the money market interest rates to be negative and consequently the longer-term interest rates decline as well. According to Arteta et al. (2018, 8) the increased lending and lower interest rates promote recovery and growth of economy and keep inflation expectations at minimum. Kerola et al. (2019, 46) on the other hand add that the negative rates have decreased the profit margin of commercial banks because the banks have been able to offer loans with smaller interest rates. Kontonikas et al. (2013, 4025) and Hosono and Isobe (2014, 19) suggest that lowering policy rates during a crisis period may in fact decrease stock prices. The reason for the decreasing prices is that lower interest rates may imply that economic situation will worsen. As a result, investors become stressed and will sell their stocks which causes the stock prices to fall.

Targeted longer-term refinancing operations

Targeted longer-term refinancing operations (TLTROs) have been launched in three series: in June 2014, March 2016, and March 2019. They are operations of the ECB where the ECB offers banks long-term funding with attractive conditions. The purpose of the operations is to increase bank lending in the economy and through the lending strengthen transmission of the monetary policy impact on economy. The amount of funding the banks can get by the refinancing operations is dependent on the loans they have issued to households and non-financial corporations. The more the banks have loans to households and non-financial corporations the more favourable interest rate they will get for funding from the ECB. (European Central Bank 2022d) Fratzscher et al. (2016, 40) state that the refinancing

operations increase liquidity in the banking system and simultaneously the balance sheet of the ECB increases.

Forward guidance

Freystätter (2016, 418-419) and Zlobins (2020, 2588) explain that forward guidance means that the ECB communicates to the public in advance the policy decisions they are going to make. The ECB has used forward guidance especially for communicating future changes in its policy rates. Forward guidance has an impact on the expectations of the interest rates which causes the rates to change. Forward guidance was added to the unconventional monetary policy toolbox in July 2013 when the inflation rate in the euro area started to rise against the will of the ECB. According to Bernanke and Reinhart (2004, 85), an example of the forward guidance is that the ECB assures to investors that the policy rates will be kept at certain level for longer period of time than they expect.

Asset purchase programme

Freystätter (2016, 418) and Urbschat and Watzka (2020, 14) explain that asset purchase programme (APP) was launched gradually starting from January 2015, since the inflation rate in Europe started to drop significantly in 2014 and the ECB had trouble maintaining price stability in the euro area. The programme is also referred to as quantitative easing. Urbschat et al. (2020, 15) state that APP consists of four programmes: "the Third Covered Bond Purchase Programme (CBPP3), the Asset Backed Securities Purchase Programme (ABSPP), the Public Sector Purchase Programme (PSPP), and the Corporate Sector Purchase Programme (CSPP)". PSPP is by far the largest scale programme of these four. Al-Jassar and Moosa (2019, 1817) and Urbschat et al. (2020, 15) agree that the purpose of APP is to encourage spending of households and businesses, enhance activity in the economy, and ultimately cause the inflation rate to rise to a favourable level. They say asset purchase programme means in practice that the central bank buys securities with funds it produces. Albertazzi et al. (2021, 1) describe the securities bought in the APP include public bonds from governments and bonds from corporates and financial sector. Freystätter (2016, 420) explains that in the process, the prices of the securities the ECB purchases increase and their profit decreases. The APP causes the demand for longer-term bonds to rise which leads to a

decrease in the yield of the bonds. Simultaneously, interest rates of the bonds increase which causes the inflation rate to rise as well. For instance, according to the studies of Altavilla, Carboni, and Motto (2015, 3) on the asset purchases of the ECB, and Joyce and Tong (2012, 382-383) who studied quantitative easing by Bank of England, asset purchase programmes cause an increase in asset prices which in turn results in smaller yields of the assets. Altavilla et al. (2015, 2) state that an announcement of upcoming implementation of APP has a greater impact on financial markets than the implementation of the programme itself. Urbschat et al. (2020, 15) state that when markets are stressed the impact of the asset purchase program is stronger compared to the situation where the markets are relaxed and the uncertainty in the markets is low. Altavilla et al. (2015, 2) has come to the same conclusion.

3 Efficient markets

First this chapter presents the theoretical framework of the study. Then it focuses on the theory of efficient markets, the efficient market hypothesis, and the random walk model. Lastly, using the theories as a background, the chapter suggests a method which may be used to measure the impact of unexpected monetary policy actions. The context of the chapter is in financial markets.

3.1 Theoretical framework

Figure 2 below presents the theoretical framework of the thesis. When the ECB decides to implement monetary policy measures it announces the decision in a press conference (European Central Bank 2022c). As Mankiw et al. (2014, 550) explain according to the efficient market hypothesis only new information of the announcement which has not been expected, has an influence on stock prices. The liquidity preference theory and the quantity theory of money suggests how the stock prices may change due to unconventional monetary policy measures. The efficient market hypothesis is explained next in this chapter and the last two theories are introduced in chapter 4.

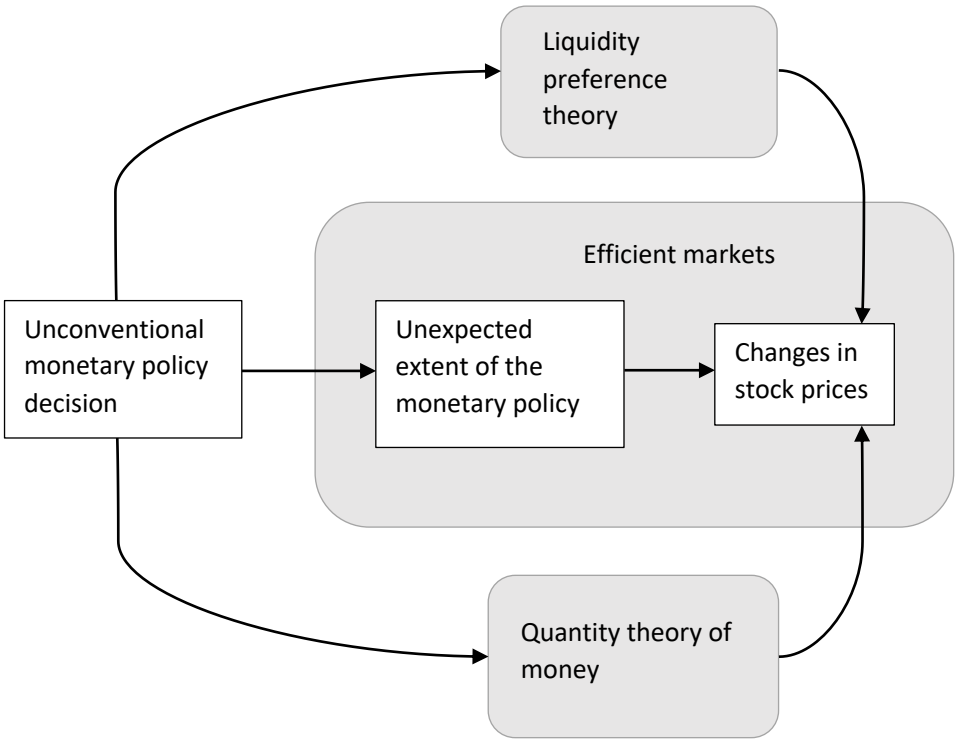

Figure 2. Theoretical framework.

3.2 Efficient market hypothesis

The theory of efficient markets by Fama (1965, 76) suggests that markets are efficient when "there are large number of rational, profit-maximizers actively competing, with each trying to predict future market values of individual securities, and where important current information is almost freely available to all participants". From the definition follows the efficient market hypothesis (EMH) according to which security prices in efficient markets should fully reflect all the information available at any given period of time. Fama (1965, 76) adds that the full reflection of the information in the prices require that there are enough intelligent and rational participants in the market who compete for the securities. Fama (1970, 383), Brown (2011, 80), and Rossi and Gunardi (2018, 183) agree that according to the EMH, trading undervalued or overestimated securities would not be possible in efficient markets. In a perfectly efficient market, according to Fama (1970, 387), the following three conditions should be met: trading securities does not cause any transactional costs, all participants in the market have all the relevant information available without costs, and all information is distributed to security prices.

Fama (1970, 387-388) adds that in practice perfect efficiency does not exist in the market and therefore for example excess returns may be possible to gain during a short period. Other examples of incomplete efficiency are that some information must be paid for, and taxes must be paid from returns. Sufficient condition for the market efficiency is that there are enough participants in the market that have the information available that influences stock prices. Knüpfer and Puttonen (2018, 168), and Metghalchi, Hajilee and Hayes (2018, 68) agree that one of the basic assumptions in financial theory is that security markets are considered efficient. Mankiw et al. (2014, 550) explain that one of the implications of the EMH is a random walk model. According to it, changes in stock prices should be impossible to predict from the information that is currently available because the prices follow a random path. Only new, unpredictable information has an impact on the stock prices. Deduction from the random walk model to this thesis is that unpredictable monetary policy decisions of the ECB would have an impact on the stock prices, and the information that is already available for a sufficient number of participants in the stock market is already included in the stock prices. The next subchapter introduces a method for separating the impact of unpredictable information from stock prices.

3.3 Unexpected monetary policy

Kuttner (2001, 523) has invented a method to separate anticipated and unanticipated components of changes in conventional monetary policy rates. In the study he used Federal funds futures data to separate the components. The results show that the unanticipated component has a stronger impact on interest rates compared to the anticipated component. Kuttner (2001, 527), Rogers et al. (2014, 752), and Haitsma et al. (2016, 102) have used futures prices as a proxy for measuring expectations of central banks' policy rates. Kuttner's method has been applied in several later studies. For instance, Gürkaynak, Sack and Swanson (2004, 3) and Altavilla, Brugnolini, Gürkaynak, Motto, and Ragusa (2019, 163) have used the method to measure monetary policy in the United States and in the euro area respectively. According to a study by Krueger and Kuttner (1996, 866) futures prices reflect forecasts of funds rate well. Gürkaynak (2005, 1) suggests that longer time horizons capture unexpected components that have longer-lasting effects in asset prices and shorter time horizons capture only short-term effects. Haitsma et al. (2016, 102) explain that the

magnitude of the unanticipated component of monetary policy may be calculated by subtracting the market rate of the futures before an announcement of change in the policy rate from the policy rate after the announcement. Bredin, Hyde, Nitzsche & O'Reilly (2009, 159) and Haitsma et al. (2016, 106) use the following equation to calculate the monetary policy surprises (which represent the unexpected component of the policy rate) from futures rates:

$$\Delta r_t^u = f_{s,t} - f_{s,t-1} \quad (1)$$

Δr_t^u in the equation is the policy surprise at time t. $f_{s,t}$ represents the futures spot rate at time t and $f_{s,t-1}$ is the futures rate before the policy announcement at time $t-1$.

After calculating the unexpected component, the expected component of the policy rate may be calculated from the equation:

$$\Delta r_t^e = \Delta r_t - \Delta r_t^u \quad (2)$$

The expected component of the change in the policy rate Δr_t^e is the difference between the actual change in the policy rate Δr_t and the previously calculated unexpected component Δr_t^u (Haitsma et al. 2016, 106).

However, Rogers et al. (2014, 752) and Haitsma et al. (2016, 106) agree that policy expectations are more difficult to measure when central banks exercise unconventional monetary policy instead of conventional policy. Therefore, the equations should be modified to reach more reliable results. Rogers et al. (2014) and Haitsma et al. (2016, 106) measure unconventional monetary policy surprises by calculating the difference between the 10-year government bond yields of Italy and Germany at time t. The equation is shown below:

$$\Delta r_t^{u,c} = \left(y_{s,t}^I - y_{s,t}^G\right) - \left(y_{s,t-1}^I - y_{s,t-1}^G\right) \quad (3)$$

$y_{s,t}^{I}$ and $y_{s,t}^{G}$ represent the yields of the Italian and German government bonds at time t respectively and analogously $y_{s,t-1}^{I}$ and $y_{s,t-1}^{G}$ represent the yields at time $t-1$. According to Haitsma et al. (2016, 102, 106), if the difference between the bond yields becomes larger after the ECB makes a policy announcement it means the announced monetary policy is tighter than the market participants had expected. If the difference decreases the policy is looser than the participants had expected. They also agree with view of Rogers et al. (2014, 770) that unconventional monetary policy aims at reducing sovereign spreads in the euro area and therefore measuring the spreads of the government bond yields is a relevant proxy to some extent for measuring the impact of the policy. Rogers et al. (2014, 770) further explain that reducing the sovereign spreads in other words means that risk premia and default risk of the member states become lower. Blanchard (2000, 298) explains that when a central bank exercises expansionary monetary policy, stock prices will increase if the policy action is more expansionary than the stock market has anticipated. If on the other hand, the policy action is anticipated fully on the stock market the prices already reflect the action and will not further react.

As an answer to the third sub question "*How can the impact of non-standard measures be measured?*", the method described above for calculating unconventional monetary policy surprises may be used to for measuring the impact of the monetary policy on stock prices.

4 Theories of money supply

This chapter introduces two theories which are related to the European Central Bank's ability to influence money supply in the economy. The theories are the quantity theory of money and the liquidity preference theory. The third sub chapter answers to the second sub question of the study "*What are the impacts of the non-standard measures on stock markets?*". Lastly, the chapter summarises the main points of chapters 2-4.

4.1 Quantity theory of money

According to Mankiw et al. (2014, 587) and Pohjola (2019, 212) the quantity theory of money measures the demand for money. The underlying idea behind the theory is that the public requires money only to complete transactions. According to the theory, money supply determines the current price level. Additionally, the growth rate of the money supply has a positive relationship with the inflation rate.

(Mankiw et al. (2014, 589-590) and Pohjola (2019, 212) agree that the theory may be written as a following equation:

$$M * V = P * Y \tag{4}$$

M represents the money supply in an economy. V is the velocity of money which means the amount of times the money supply M is used for transactions within a year. P describes the general price level of an economy and Y is the gross domestic product (GDP) of the economy per year. $P * Y$ describes the value of transactions within a year and therefore $M * V$ measures the demand for money.

Pohjola (2019, 212) further explains that the quantity theory creates causal relationships between the variables of the equation through three assumptions. The first assumption is that in the long-term GDP per year is on its natural level Y_N. Secondly, the velocity of money V is constant. Thirdly, central banks may control the money supply M. With the assumptions the price level P of an economy is determined by the money supply M, and furthermore, increase in money supply M affects the rate of inflation in an economy.

Pohjola (2019, 213) adds that the theory has a smaller significance for monetary policy than it has for economics as central banks are not able to fully control the supply of money since also banks may create money by lending it. Another criticized aspect of the theory is related to spending money. According to Marcuzzo (2017, 261), against the quantity theory of

money when the ECB has increased money supply in the economy by quantitative easing the price levels have scarcely been affected by the expansionary policy and the inflation rate has not increased as expected. Instead increasing money supply has caused an increase in asset prices. The quantity theory of money expects that all the money in the economy is spent but in reality, some of it may be saved for later and therefore increase in money supply may have a positive influence on stock markets. Hillinger, Süssmuth and Sunder (2015, 317) state that the quantity theory poorly explains the relationship between money supply and inflation when analysing countries with low inflation rates. For high inflation rates the theory holds true according to them. Also, Teles, Uhlig and Valle e Azevedo (2016) agree that the validity of the theory is the highest in high-inflation regimes. Marcuzzo (2017, 262) suggests that a better theory for explaining how expansionary monetary policy affects asset prices is the liquidity preference theory.

4.2 Liquidity preference theory

According to Hayes (2017, 405), liquidity may be defined as "being able to meet contractual obligations as they fall due" "in money-using, market-oriented systems." Oreiro, de Paula and Heringer (2020, 130) add that liquid assets may be "converted quickly and readily into money". Hayes (2017, 408) explains that the reason for liquidity to have value is because future is unknown. The value of liquidity rises if the fear of negative and unpreventable occasions increases. Pusch (2017, 537) and Oreiro et al. (2020, 130) state that when confidence in the economy decreases demand for liquid assets, such as cash holdings and other close substitutes for money, increase as a precaution. The shift causes market participants to trade less liquid assets for more liquid ones. Oreiro et al. (2020, 130) explain that the return of liquid assets is smaller than less liquid assets. The implicit return that an investor is ready to sacrifice for holding liquid assets compared to less liquid assets is called liquidity premium. Due to the liquidity premium and low return of liquid assets, according to Wen (2015, 2), holding large amounts of cash may result in lower real wealth because inflation decreases the utility of liquid assets more than of less liquid assets.

For the context of the study, based on the liquidity preference theory, during the time of crisis and stressed markets market participants would prefer highly liquid assets compared to assets that are less liquid. According to Asensio (2017, 337-339) higher demand for liquidity will increase interest rates but when central banks increase money supply with monetary policy actions the interest rates will fall. However, as suggested by Mankiw et al. (2014, 703-704) if, due to the expansionary monetary policy, the money supply increases over the level that banks, businesses, and consumers are willing to possess cash holdings the excess money will be used to buy assets, such as stocks and bonds. Therefore, the increase in money supply which is caused by loose monetary policy and furthermore by unconventional monetary policy, may increase the demand of stocks which causes stock prices to rise.

4.3 Impact of non-standard measures on stock prices

Based on the previous literature and the theories explained above, the second sub question "*What are the impacts of the non-standard measures on stock markets?*" may be answered. the impact of negative interest rate policy on stock prices is controversial. Stock prices could decrease if investors expect the economic situation to worsen but on the other hand, lower interest rates decrease the return of interest-bearing assets and therefore investors may rebalance their portfolios by increasing the portion of stocks in them. Based on the liquidity preference theory, as a result of implementation of TLTROs which increase liquidity in the banking system, excess liquidity may be allocated to more profitable assets such as stocks. As the demand for the assets increase, also the prices of the assets will increase. Therefore, TLTROs may have a positive relationship with stock prices. Forward guidance is used to calm markets. Calmer investors may prefer less liquid assets than stressed ones and therefore they may keep more stocks in their portfolios than in stressed market conditions and the stock prices would rise. The impact of asset purchase programmes on stock prices depends on the asset type the ECB purchases in the programme. When the ECB purchases bonds which causes the bonds to become less attractive, investors' demand for stocks will likely increase since the stocks become more attractive and higher demand will result in higher stock prices. All the non-standard measures considered, the overall impact of the

unconventional monetary policy on the stock prices is likely positive. Therefore, a hypothesis for the main research question is formulated as follows:

H1: Monetary policy surprises have a positive relationship with stock prices of the banking sector.

4.4 Summary of theoretical framework

The theoretical framework of the thesis consists of background information on the ECB's monetary policy and three theories which are the efficient market hypothesis, the quantity theory of money, and the liquidity preference theory. This subchapter recalls the main points of the topics before continuing to discuss methodology of the study. Firstly, the ECB is responsible for price stability and steering economy in the euro area to keep conditions for economic growth favourable. To reach its objectives, the ECB exercises monetary policy which may be divided into conventional and unconventional monetary policy. Conventional monetary policy consists of standard measures which have been effective until the global financial crisis hit in 2008. During the crisis, the ECB started using non-standard measures since the banking system was malfunctioning and the standard measures could not ease the situation. The main non-standard measures are negative rate on the deposit facility, forward guidance, asset purchase programmes, and targeted longer-term refinancing operations. Negative rates cause depositing funds to the ECB unfavourable which leads banks to find more profitable ways to invest their funds. Forward guidance calms the markets and decreases uncertainty. Via asset purchase programmes the ECB attempts to increase interest rates and inflation. Lastly, the refinancing operations offer funds to banks at attractive conditions and encourages bank lending. Monetary policy is transmitted to the economy via different channels. The impact of non-standard measures is transmitted particularly via direct pass-through channel, portfolio rebalancing channel, and signalling channel.

The efficient market hypothesis was introduced by Fama in 1965. According to the hypothesis, in the context of financial markets, security prices should fully reflect all the information available in the market if the market is efficient. Financial markets are

considered to be efficient even if they do not completely fulfil the assumptions of the efficient markets. For example, asymmetric information exists in the markets, returns are taxed, and irrational behaviour may occur among market participants. Based on the theory, the impact of monetary policy on stock prices could be measured by separating anticipated and unanticipated components of monetary policy rates. The method is suitable for measuring conventional monetary policy since the main tool of the policy was to steer the policy rates. Unconventional monetary policy on the other hand is not as straight-forward to calculate since policy rates are in a minor role in it. Instead, a proxy for measuring the unanticipated component (which reflects the new information in the market that is not yet included in stock prices) of the policy may be created. One option for a proxy is to measure changes in spreads of government bond yields before and after the ECB announces policy actions as explained in more detail in subchapter 3.3.

Quantity theory of money explains how increasing money supply by central banks increases liquidity in an economy and measures demand for money. According to it, rise in the money supply causes higher inflation. The theory has been criticised for not reflecting reality well since it assumes that all the money in the economy is used for transactions and spent. The theory for example ignores investing and saving in the economy. The criticism of the theory suggests that when the ECB's unconventional monetary policy actions increase liquidity in the economy some of the liquidity may be used for securities such as stocks. Furthermore, increasing liquidity could increase the demand of stocks and therefore increase their prices.

Liquidity preference theory suggests that when a fear for worsening conditions in an economy increases the preference for highly liquid assets increases. Liquid assets involve lower risk and therefore lower profit than less liquid assets. During uncertain times investors are ready to trade profit for possessing less risky assets. In the context of the global financial crisis starting from 2008, the theory would suggest that as the demand for liquidity increases simultaneously the demand for less liquid assets such as stocks decreases. However, if the available liquidity exceeds the desired level which market participants are ready to possess in liquid assets, they may want to invest the exceeding part to more profitable assets such as stocks. Therefore, due to the ECB's expansionary monetary policy the demand for stocks

and furthermore stock prices may in fact increase. The theories support the hypothesis according to which loosening monetary policy would increase stock prices and correspondingly tightening the policy would decrease the prices. The next chapter describes the method used to test the hypothesis in the study.

5 Methodology

The quantitative study of this thesis is conducted with linear regression analysis. This chapter describes the assumptions for the regression analysis, the regression model that will be estimated in chapter 6 and finally the chapter presents the variables and data used in the analysis. The analysis is conducted with Stata.

5.1 Linear regression analysis

Linear regression analysis is a widely used statistical method for quantitative analysis. It estimates how independent variables affect a dependent variable. Based on the analysis, one can estimate if independent variables have an impact on the issue that is being studied (which is measured with a dependent variable) and how large the influence of the independent variables is on the issue. In practice, the estimation is calculated from observations of the variables and based on the location of the variables a regression line may be drawn. (Hill, Griffiths & Lim 2018, 49)

According to Hill et al. (2018, 50-51, 198) the general econometric equation for the regression line is as follows:

$$y = \beta_1 + \beta_2 x_1 + \cdots + \beta_n x_n + \varepsilon \quad (5)$$

In the equation y represents a dependent variable, β_1 is a constant term called an intercept, and x_1,… , x_n are independent variables. β_2, …, β_n are the estimated parameters of the model and represent the slope of the independent variables x_1,… , x_n. Lastly, ε is a residual of the model, also called as an error term. The residual is a part of the model that the model cannot explain, and its magnitude is unknown. Its magnitude depends on the extent to which the independent variables can explain the dependent variable. If for instance, an independent variable, that would significantly explain the variation of the dependent variable, is not included in the model the residual would be larger compared to the model which includes the variable.

Hill et al. 2018, 61) explain that an estimation model requires a formula according to which observations in a sample are estimated. One of the formulas is the least squares principle. It means that a regression line of the model is formed based on "the sum of the squares of the vertical distances from each point to the line as small as possible". Squaring the distances prevents large negative and positive distances from cancelling out by each other. Hill et al. (2018, 58, 198, 203-204) adds that in a multiple regression model, which means that the model contains more than one independent variable, the following seven assumptions should be true for the results of the estimation with the least squares principle to be reliable:

1. The value of y for every value of x follows the equation $y = \beta_1 + \beta_2 x_1 + \cdots + \beta_n x_n + \varepsilon$.
2. The expected value of the residual is zero, $E(\varepsilon) = 0$, because change in y depends on the values of independent variables.
3. The variance of the residual is constant, $var(\varepsilon) = \sigma^2 = var(y)$.
4. The covariance of each residual pair is zero, $cov(e_i, e_j) = cov(y_i, y_j) = 0$.
5. Independent variables are not random variables and the variables have at least two different values.
6. The residuals are normally distributed if dependent variable y is normally distributed and vice versa.

7. The independent variables are not fully collinear.

If the assumptions are not fulfilled the estimated parameters of the model are biased and/or their standard errors are incorrect or unreliable. The least squares estimates β_2, …, β_n are the best for the regression line if all the assumptions are valid. (Hill et al. 2018, 61)

5.2 Description of the regression model and the variables

The econometric model for the regression analysis in this study is based on the studies of Rogers et al. (2014) and Haitsma et al. (2016), and is as follows:

$$R_t = \beta_1 + \beta_2 \Delta r_t^{u,c} + \delta X_t + \varepsilon_t \quad (6)$$

The model is static which means that the value of the dependent variable at time t depends on the values of the independent variables at time t. The dependent variable of the model, R_t, describes the changes in stock prices in the banking sector at day t. The variable is calculated as a logarithmic return from the following equation introduced by Haitsma et al. (2016, 105):

$$R_t = \ln\left(\frac{p_t}{p_{t-1}}\right) \quad (7)$$

In the equation, p_t is the closing price and p_{t-1} is the opening price of the index. The index used is STOXX Europe 600 Banks. According to Qontigo (2022b) it is one of the twenty STOXX Supersector indices and it contains 39 European companies whose main source of revenue is banking. The data is gathered from Refinitiv Eikon database with code “STOXX EUROPE 600 BANKS E - PRICE INDEX” and it is daily and presented in euros.

$\Delta r_t^{u,c}$ in the model represents the unexpected unconventional monetary policy surprise in the model. It is calculated by subtracting changes in spreads of Italian and German government bond yields, as presented in chapter 3.2. The equation for the calculation is presented by Haitsma et al. (2016, 106):

$$\Delta r_t^{u,c} = \left(y_{s,t}^I - y_{s,t}^G\right) - \left(y_{s,t-1}^I - y_{s,t-1}^G\right) \quad (3)$$

$y_{s,t}^I$ and $y_{s,t}^G$ represent the yields of the Italian and German government bonds (10 years maturity) at time t respectively and $y_{s,t-1}^I$ and $y_{s,t-1}^G$ represent the yields at time $t-1$. The data used to calculate the monetary policy surprise is collected from Refinitiv Eikon database with codes "GVIL03(CM10) - GVIL03(CM10)" for Italian government bonds and "GVBD03(CM10) - GVBD03(CM10)" for German government bonds. The data is daily.

X_t in the model, is a control variable representing the development of the world economy excluding Europe. The world economy affects the economy in Europe and therefore has an impact on the stock prices in Europe. Adding the variable should increase the coefficient of determination of the estimation model and simultaneously decrease the error term. The variable is formed by subtracting MSCI Europe Index, which represents the development of the economy in Europe, from the MSCI World Index. By calculating the difference between the indices, the effect of the economic development in Europe is excluded from the development of the world. The MSCI World Ex Europe index is used in the study, and it is gathered from Refinitiv Eikon database with code "MSCI WORLD EX EUROPE E - PRICE INDEX". The index already excludes Europe from the rest of the world. The data is presented in euros, and it is daily. The variable is calculated the same way as the banking sector return R_t except without taking the logarithm of the division of the prices.

Lastly, β_1 is the constant of the model, β_2 and δ are the intercepts of the monetary policy surprise and the world economy respectively, and they describe the impact of the variables to the logarithmic return of the stock index. ε_t is the error term of the model.

5.3 Description of the data

The data used in the study are intraday data because, as (Rogers et al 2014, 753) explain intraday data capture the effects of the monetary policy actions the best and minimises the risk of contaminating the data from other factors that influence the stock prices. However, to capture the impact of monetary policy announcements the observations included in the regression analysis includes only the dates when the announcements were made. The variables therefore measure the differences in them one day before the announcement and on the day when the announcement was made. Haitsma et al. (2016, 106) explain that the ECB announces the policy decisions after the ECB Governing Council has held a meeting. The decisions are further explained in a press conference by the President and the Vice-President of the ECB. During 2009-2019 the Governing Council has met every four to six weeks (European Central Bank 2022c). During the study period the Governing Council held 112 meetings. The dates and the policy decisions of the meetings are presented in Appendix 1. Empty cells in the table mean that new monetary policy actions are not decided in the meeting.

Descriptive statistics of the dependent and independent variables of the regression model are presented in Table 1.

Table 1. Descriptive statistics of the variables.

Variable	Return of banks, R_t	Policy surprise, $\Delta r_t^{u,c}$	World economy, X_t
Mean	-0.0000186	0.0000865	1.000498
Standard deviation	0.017093	0.0834994	0.008974
Minimum	-0.156216	-0.7628999	0.9392141
Maximum	0.134889	0.5976	1.059609
Observations	2868	2868	2868

The values of each variable are presented in daily decimal numbers. The means of the logarithmic return of banks and monetary policy surprises are close to zero and mean of world economy variable is close to one. Since the calculation method of each variable is different comparison of the statistics of the variables is not meaningful. Even though each variable has 2868 observations only the observations of the ECB monetary policy announcement dates (112 observations) are used for the regression analysis to capture only the impact of the policy actions and to minimise the impact of other effects that may influence the stock prices.

Figure 3 illustrates that during the period of the study, 2009-2019, the yield of 10-year maturity government bonds of Italy has been higher than the yield of government bonds of Germany. Both yield curves follow a similar trend, but fluctuations are steeper with Italian bonds. The points in the curves illustrate the dates of the ECB press conferences. Thus, the figure presents how the bond yields have changed from a conference to conference. The graph shows that for example from 2014 to 2015 the spread of the bond yields has decreased which would mean that the monetary policy of the ECB has been loose and has eased the economy. During those years the ECB has launched targeted longer-term refinancing operations which encourage bank lending and growth of economy. In 2018 the spread has widened considerably which may be due to ending asset purchase programme as shown in Appendix 1. Ending the asset purchase programme could mean tightening of the monetary policy.

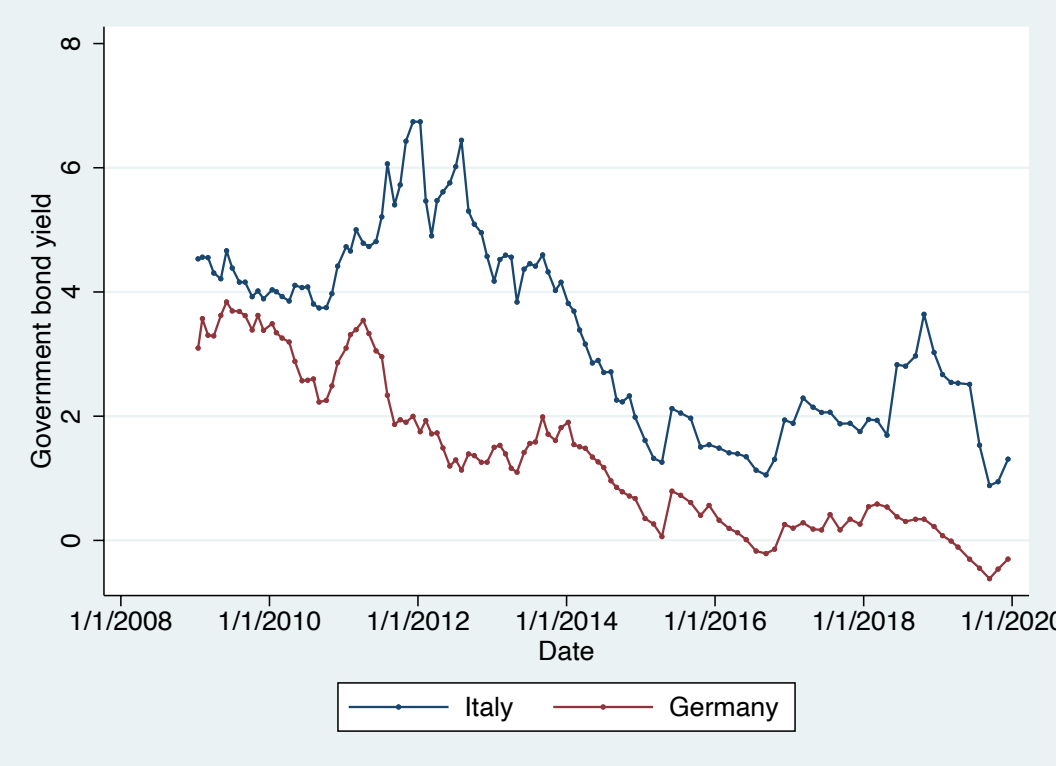

Figure 3. Government bond yields of Italy and Germany 2009-2019.

6 Results

This chapter presents the results of the regression analysis which is conducted as explained in the previous chapter. Next the validity of the assumptions, which is explained in the previous chapter is examined graphically and with statistical tests, and the effectiveness of observations is diagnosed. Finally, the chapter discusses the validity and the reliability of the data.

6.1 Impact of monetary policy on performance of stocks of banks

The detailed results of the regression analysis for the model which estimates the development of the stock prices in the banking sector in Europe with monetary policy surprises and the world economy development excluding Europe are presented in Appendix 2. F-test results,

coefficients of determination, coefficients of the variables, standard errors and P-values of the estimation are shown in Table 2. According to the results, the coefficient of determination of the model is rather large, approximately 53.7 %, the value of the F-test is 63.12, and the model is statistically significant (Prob > F = 0.0000). The result of F-test means that at least one of the coefficients of independent variables differs from zero.

Table 2. Impact of monetary policy surprises on STOXX Europe 600 Banks index.

F test		Coefficients of determination	
F (2, 109)	63.12	R^2	0.5366
P > F	0.0000	Adjusted R^2	0.5281
Variable	Coefficient	Standard error	$P > \|t\|$
Policy surprise, $\Delta r_t^{u,c}$	-0.0758792	0.0129112	0.000
World economy, X_t	1.068388	0.1260087	0.000
Constant	-1.069405	0.1262319	0.000

The variables and the constant are statistically significant at 1 % risk level. The estimation shows that when the logarithmic return on the banking sector increases by one unit the monetary policy surprise decreases by -0.08 units and the world economy development increases 1.07 units. In other words, if the monetary policy by the ECB is looser than the stock market participants had expected the prices of the stocks increase in the banking sector. Development of the world economy excluding Europe has a positive correlation with the banking sector stock prices.

The effect sizes of each independent variable in the linear regression model may be measured statistically with effect sizes test (Stata 2022). The effect sizes test for the estimated model shows that 24.1 % of the variation in the dependent variable is explained with the monetary policy surprise variable and 39.7 % is explained with the world economy control variable. (Appendix 3) The effects of each independent variable may be measured also with semi partial correlation coefficients where the effect of other variables is removed from the variable which is examined. In this case, the semi partial correlation coefficients are smaller

with both independent variables compared to the effect sizes measured. For the monetary policy surprise variable, the coefficient is 14.7 % and for the world economy variable it is 30.6 %. Both coefficients are significant at 1 % risk level. (Appendix 4) The tests confirm that the monetary policy surprises indeed have an impact on the stock returns in the banking sector.

6.2 Validity and reliability

This subchapter focuses on examining the assumptions that OLS estimation method requires to be the best linear and unbiased estimation method. Additionally, the subchapter discusses the validity and reliability of the data. According to Ihantola & Kihn 2011, 40), validity means the ability to "draw valid conclusions from a study given the research design and controls employed." Validity may be categorized as internal and external validity. According to Abernethy, Chua, Luckett & Selto (1999, 16), internal validity means that "variations in the dependent variable is due to, or a result of, variation in the independent variables." External validity on the other hand means according to Ihantola et al. (2011, 42-43) the extent to which a researcher may draw general conclusions based on the study. Additionally, they explain that reliability describes the consistency of variables in measuring what they are intended to measure.

Specification of the model and linearity

The dependent variable should have a linear relationship with independent variables as stated in assumption 1 for an estimation model in subchapter 5.1. The linearity may be studied with component-plus-residual scatter plots of independent variables. Scatter plots of the independent variables (Appendix 5) show that both variables have a linear relationship with the dependent variable, return of the index. According to Hill et al. (2018, 280-281) a model is well specified if it includes the correct variables, and any relevant variables are not omitted from the model. The specification of the model may be measured with the Ramsay Regression Specification Error Test (RESET test). The null hypothesis of the test is that the model has no omitted variables. According to the RESET test results the model is specified correctly, and the variables do not require further modifications since the P-value of the test

is higher than the 5 % risk level i.e., the null hypothesis cannot be rejected (Prob > F = 0.6077) (Appendix 6).

Independence of residual term and independent variables

The residual term should not correlate with independent variables. The relationship may be illustrated with residual-versus-predictor plots. If the observation points in the plot do not have a trend the residual does not correlate with independent variables. The residual-versus-predictor plots of the monetary policy surprise and the world economy variables show that they are not correlated with the residual. (Appendix 7) The number of observation points in the plot with the monetary policy surprise variable is low with the smallest and largest values of the variable and most of the values lie in the area where the variable values are around zero. The observation points in the second plot with the world economy variable are more scattered compared to the first plot. Both plots have one clear outlier.

Homoscedasticity

According to Hill et al. (2018, 370-371, 387), homoscedasticity means that the variance of the residual term is constant i.e., the variance does not depend on the values of the dependent and the independent variables of the estimation model (assumption 3). Homoscedasticity may be tested with Breusch-Pagan test and White test. The null hypotheses for both tests are that the model is homoscedastic. Based on Breusch-Pagan and White tests (Appendix 8), the estimation model is homoscedastic, and the variance of the residual is constant as P-values of Breusch-Pagan and White tests are 0.8805 and 0.2749 respectively.

Autocorrelation

Autocorrelation means that subsequent observations in the dataset correlate with each other which violates assumption 4. Autocorrelation is a common challenge with time series data. Autocorrelation may be tested with Breusch-Godfrey test and with correlograms of residuals. The correlations outside the grey area in the correlogram are statistically significant and suggest that the model is autocorrelated. (Hill et al. 2018, 424-426) Some

residuals of the estimated model in a correlogram are located outside the grey area which means autocorrelation to some extent exists between the observations. On the other hand, according to Breusch-Godfrey test the model is not autocorrelated (Prob > chi2 = 1.000). The correlogram and the results of Breusch-Godfrey test are presented in Appendix 9.

Multicollinearity

Multicollinearity means that independent variables in an estimation model correlate with each other which causes the assumption 7 not to hold. If multicollinearity exists separating the influence of the multicollinear independent variables to the dependent variable becomes challenging. It may be observed with correlation tests of independent variables and with variance inflation factor test (VIF). (Hill et al. 2018, 288-291) The correlation test of the monetary policy and the world economy variables shows that the correlation between the variables is negative and weak since the correlation coefficient is -0.1645 (Appendix 10). Hill et al. (2018, 289-290) state that VIF test calculates how many percent of the variation in an independent variable is not explained with other independent variables of the model. If the values are close to 1 multicollinearity does not exist between the independent variables. VIF test gives a value of 1.03 for both monetary policy surprise and world economy variables which means multicollinearity does not cause bias on the estimation model (Appendix 10).

Normally distributed residuals

Residual term and the dependent variable should be normally distributed according to the assumption 6. In small samples the estimated model may be biased if the assumption for normal distribution in not valid. Normal distribution may be observed graphically with histograms of the residuals and with normal probability plot. Statically it may be measured with Shapiro-Wilks test for normal distribution for instance. For large samples, Shapiro-Wilks test will always reject null hypothesis which means that according to the test the residual term is not normally distributed. Therefore, the distribution of the residual in this study is observed graphically. A graph representing a histogram of the residuals and a normal probability plot are presented in Appendix 11. The residual of the estimation model seems to be normally distributed rather well based on the shape of the histogram of residuals. Also,

the residuals follow quite well the line of normal probability plot which means that the residuals are normally distributed.

Stationarity

Hill et al. (2018, 428-429) explain that stationarity means that probability distribution of a stochastic process of time series depends on time. Stationarity may be observed with graphs of variables of the model versus time. Based on the line plots of each variable versus time, the time series is strongly stationary since the plots do not have a trend (Appendix 12).

Endogeneity

The assumption about the independent variables not being random (assumption 5) does not hold for the independent variables of the regression model since the bond yields and world economy price index are not fixed and known before occurring but they are determined by supply and demand. Violation of the assumption may lead the least squares estimator to be biased as the properties of the estimator will "depend on the random independent variables' characteristics (Hill et al. 2018, 482). Hill et al. (2018, 88) explain that due to the random variables, endogeneity may exist in the model. It means that an independent variable in a regression model correlates with the residual. The estimation model is not tested statistically for endogeneity because in practice the testing is challenging. Endogeneity may cause the model in the study to be biased as the ECB may react to changes in stock markets via the monetary policy as explained by Haitsma et al. (2016, 102). However, according to Kontonikas et al. (2013, 4026) the concern for endogeneity is decreased when using daily data since unlikely the development of stock prices causes an impact on monetary policy actions on the same day as the development occurs. Also, Fratzscher et al. (2016, 37) agree with endogeneity not being a major concern when using daily data.

Diagnostics of observations

The model should not contain observations that are considered as outliers. Outliers may cause the model to be biased and its standard errors may be faulty. Outliers may be observed with a leverage versus residual plot as presented in Figure 4.

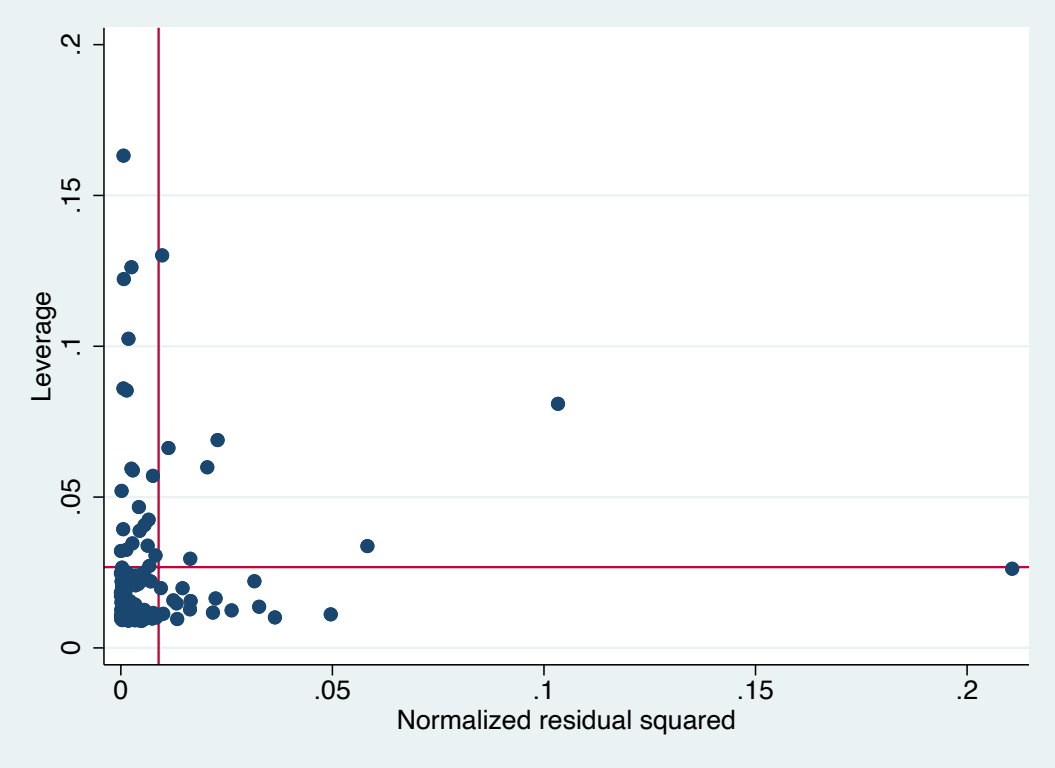

Figure 4. Leverage versus residual plot of the regression model.

In a leverage versus residual plot all the observation points should ideally be within the red lines on the left-hand side and at the bottom of the graphing area. According to the plot of the estimated regression, the location of one of the observations clearly differs from the rest of the observations. The model might be improved by removing the outlier however, the leverage value of the outlier is rather small and therefore, it does not pose a severe threat for the model to be biased.

Influence of observations on coefficients

Accordinng to UCLA (2022) the influence of observations on the parameter estimates may be observed with spike graphs. In spike graphs, the observations that have substantially large spikes have a higher impact on the parameter estimates of the independent variables than the rest of the observations. The spike graphs of both independent variables and the whole estimation model are presented in Appendix 13. According to the graphs notably large spikes are located on the left side of the graph which means that the observations in the beginning of the 2009-2019 time period influence more the coefficients than the rest of the time period. The higher influence of observations could be explained by the emerging crisis period which causes remarkable uncertainty in an economy which may be seen for instance as larger fluctuations in the stock market. One solution could be to narrow down the time period of the study further to start from 2010 for example. Another explanation could be that the ECB has announced more radical policy decisions than expected to tackle the crisis. For instance, as seen in Appendix 1, in the beginning of 2009 the ECB had decreased MRO rate three times from 2.00% to 1.50% and finally to 1.25%. It also introduced longer-term refinancing operations programme. Therefore, deleting the highly influential observations from the data could harm the reliability of the study due to the nature of the data.

Validity and reliability of the data

In the thesis, several academic journals are used for theoretical framework and more than one researcher has used the study method for measuring impact of unconventional monetary policy in their research. The validity could be further increased by measuring the impact of the unconventional monetary policy by alternative research methods. The dataset used in the regression analysis is rather small (112 observations) even if the data collection period is ten years. The small number of observations may cause the results to be less accurate compared to larger datasets. The accuracy of the study could increase if the same procedure was repeated for instance after five years when the when more data is available assuming the non-standard measures of monetary policy are still in use.

A straight-forward variable for describing changes in stock prices is formed from STOXX Europe 600 Banks index. Validity of the variable is rather high as the changes in prices may

be measured accurately from the index data. The control variable of world economy development similarly to the changes in stock prices present the changes in the economy development straight-forwardly. Including control variables in the study increases the internal validity of the research. The independent variable describing the changes in monetary policy actions is constructed from the yields of German and Italian government bonds. It is a proxy for measuring the changes in unconventional monetary policy as an exact measure for it does not exist. Using a proxy may decrease the validity of the research since it may not fully reflect a variable that is intended to be measured. The spreads of the bond yields may not be completely caused by monetary policy actions, but also other factors may affect the spreads. To improve validity alternative variables describing the unconventional policy should be searched. The results cannot be generalized for example to other economic areas based on the study without further research but since central banks function quite similarly to each other similar results could be expected for other economic areas.

The data of the research is collected from Refinitiv Eikon. It "is an open-technology solution for financial markets professionals, providing access to industry-leading data, insights, and exclusive and trusted news" (Refinitiv Eikon 2022). Source of the STOXX Europe 600 Banks index is STOXX, which is part of Qontigo. Refinitiv Eikon has used data from MSCI for the world economy dataset. The origin of the bond yield data is Refinitiv Eikon. Qontigo is a "leading global provider of innovative index, analytics and risk solutions" (Qontigo 2022a). MSCI provides "critical decision support tools and services" globally (MSCI 2022). All these data-providing companies are well-known and trustworthy and therefore the data collected for the study are rather reliable. To further investigate the reliability of the data collected, the data collection, data processing, and analysis should be repeated multiple times. The results should then be compared to each other. The smaller the variation between the results the better the reliability of the data is. Describing the data collection process and data manipulation increases the reliability of the study since it allows the study to be repeated.

7 Discussion and conclusions

The study examines what kind of impact the monetary policy decisions of the European Central Bank have on the stock prices of European banks which are included in STOXX Europe 600 Banks index. The impact is estimated with a linear regression model which contains two independent variables describing monetary policy surprises and the development of world economy. The time period of the study is 2009-2019.

The study is largely based on the efficient market hypothesis. It states that only new information affects stock prices, and the influence is fully reflected on the prices when the stock market functions efficiently. A method for measuring the unexpected new information concerning monetary policy actions is based on the implications of the efficient market hypothesis. The independent variable presenting the monetary policy surprises is formed from the changes in the spread of Italian and German 10-year government bond yields one day before the European Central Bank announces new policy measures and on the day of the announcement.

According to the regression analysis results, the relationship between the logarithmic return of stocks of banks and the monetary policy surprise variable is negative. Negative values in the monetary policy surprises mean that the spread between the Italian and German 10-year government bond yields has decreased from a day before the ECB's monetary policy announcement to the announcement day. The decrease in the spread means that the monetary policy action has been more expansionary than what the market has expected. While the policy action affects the bond yields, it also affects stock prices. The announcement, i.e., new information that is not yet reflected in stock prices, causes a shock in the stock market and the prices of stocks will increase. On the other hand, an increase in the spread of the bonds, i.e., positive observations in the monetary policy surprise variable, means that the monetary policy is tighter than the stock market had expected and after the announcement of the policy actions the stock prices of banks will decrease.

The relationship between the two variables is as expected based on the theories of efficient market hypothesis and liquidity preference. The study would suggest that the hypothesis "*H1: Monetary policy surprises have a positive relationship with stock prices on the banking sector"* is supported. The world economy surrounding Europe has a positive relationship with the logarithmic return of stocks of banks and the world economy variable explains more of the variation in the return of stock than the monetary policy surprises. The relationship means that since the economy has become global, the stock prices are affected by events occurring outside Europe.

The results of the regression analysis are statistically significant. Based on the results, monetary policy surprises have an impact on stock prices: when the monetary policy measures are looser than expected stock prices of banks increase and when the measures are tighter than expected the prices decrease. As efficient market hypothesis suggests that new information has an impact on stock prices, the results of the study seem to correlate with the theory. On the other hand, the results differ from what is expected based on the quantity theory of money. As discussed in subchapter 4.1, the theory is criticized for not reflecting the real effect of increasing money supply on the economy. The results seem to support the criticism. According to the liquidity preference theory, the demand of highly liquid assets is supposed to increase during a crisis. The study does not offer an answer to whether that is the case for the Euro area during 2009-2019. Instead, it supports the proposition of Mankiw et al. (2014, 703-704) according to which the increase in money supply through exercising expansionary monetary policy may lead to an increase in stock prices due to higher demand of stocks caused by possessing excess money. Secondly, the results favour indirectly the view of Asensio (2017, 337-339) who states that increasing money supply decreases interest rates. Lower rates cause the demand for interest-bearing securities to decrease since their expectations for profit decrease and lead investors to seek alternative investment options such as stocks. As a result, the demand and prices of the alternative investment options would rise.

One of the closest studies related to the thesis is conducted by Rogers et al. (2014, 787-788) as they use a similar study method and measure monetary policy surprises from Italian and

German government bond yields as in the thesis. They study how the unconventional monetary policy announcements of four central banks, the Federal Reserve, the ECB, the Bank of England, and the Bank of Japan, affect financial markets, particularly stock prices, bond yields, and exchange rates. When it comes to studying the euro area, the Rogers et al. (2014, 785, 788) learn that unconventional monetary policy actions have eased financial conditions. They have also concluded that monetary policy shocks indeed affect asset prices which is in line with the results of the thesis. They further argue that especially in the Europe, the measured impact of the monetary policy is largely influenced by the ECB's ability to signal their intentions credibly (Rogers et al. 2014, 785). This perspective would mean that forward guidance is potent policy tool to influence economic development and for instance stock prices. Rogers et al. (2016, 787) states that their results suggest that stock prices are influenced less to tightening monetary policy than to loosening policy. The study method in the thesis is not able to measure the differences in the extent of impact of tight and loose monetary policy.

Another study close to the thesis methodology-wise is conducted by Haitsma et al. (2016, 102, 108). They focus on studying the impact of the ECB's monetary policy, both conventional and unconventional, on stock portfolios of different sectors. According to their study the looser than expected monetary policy results in an increase in stock prices of banking sector. Correspondingly unexpected tightening of the policy leads to a decrease in the stock prices. These results are similar to those of this thesis. When the results of the conventional and unconventional monetary policies are compared, Haitsma et al. (2016, 113) have found stronger impacts on stock prices when utilising unconventional policy than during the conventional monetary policy era. Haitsma et al. (2016, 113) suggest that the impact of the monetary policy on stock prices differs depending on whether the policy action occurs during a crisis period or during ordinary times. Their results hint that during a crisis tightening of the unconventional monetary policy in fact would result in higher stock prices than during a non-crisis period. One explanation for the differing results could be the view of Hosono et al. (2014, 19), according to which loosening monetary policy during a crisis could signal investors that economic conditions are worsening. The view is also in line with the liquidity preference theory on higher demand for liquidity during a crisis. The study method of the thesis does not classify crisis and non-crisis observations and therefore the

results do not consider the changes in the impact of monetary policy on stock prices over time.

Unalmis et al. (2015, 8-11) have studied the effects of the Federal Reserve's monetary policy shocks in the US. They have found that stock prices are indeed affected by monetary policy surprises. Easing policy increases stock prices and tight policy causes a decline in the prices. In more detail, their results show that conventional policy shocks have a larger impact on stock prices than unconventional policy shocks. As the context of the study differs from the context of the thesis the results are not fully comparable. However, as central banks function in a similar manner and their policy tools are similar the results of Unalmis et al. (2015) would indicate that similar results could be expected in the euro area. Therefore, the study supports the validity of the findings in the thesis.

The study contributes to literature the following ways. It explains what kind of unconventional monetary policy tools the ECB utilises to reach price stability in the Euro area, how the tools are used, and how the monetary policy actions are transmitted to the economy. Most importantly the thesis supports conclusions of previous studies according to which loose unconventional monetary policy has a positive influence of stock prices in the Euro area after the global financial crisis emerged. Lastly, the thesis supports the validity of the efficient market hypothesis in a way that new information will be reflected on stock prices.

One of the limitations of the study is that it is unable to distinguish the magnitude of impact of each unconventional monetary policy measure as the model measures the overall impact of the unconventional monetary policy. Secondly, as the data is intradaily, it measures changes in the monetary policy with interval from a previous day until the end of the policy announcement date. Therefore, the data does not catch immediate effects of the policy announcement, for instance an effect after thirty minutes after the announcement. Also, long-term effects of the policy actions cannot be evaluated based on the study. Thirdly, the regression model does not consider other matters that may influence STOXX Europe 600

Banks index but expects that changes in stock prices occur solely due to monetary policy announcements and the world economy development (excluding Europe). In reality, the index may be affected simultaneously with the monetary policy announcements, for instance, by news concerning individual banks included in the index, by spillover effects of other central banks' policy actions, and generally by other events occurring in the European stock market. Therefore, the estimated regression model may not accurately measure the exact effect of monetary policy on stock prices of European banks. The proxy for measuring monetary policy may not be applied to other economic areas as it is if impact of unconventional monetary policy of other central banks on security prices is desired to investigate. Instead the proxy should be modified in order to use a similar study method which may cause a challenge if the results of different economic areas are to be compared as the results may not be commensurate.

To evaluate the reliability of the study and to further investigate the influence of the unconventional monetary policy on stock prices, a similar study could be conducted using a different study method. For example, Andersson (2010, 117) has studied the effect of monetary policy decisions on stock market in the Euro area and in the United States through changes in the volatility of stocks. The study ignores the impact of the ECB's communication strategies on the effectiveness of the policy announcements and their influence on stock prices. Studying the communication of the ECB would give more insight about how the actions of the central bank influence for instance securities or more generally the economy of the euro area. For example, Ehrmann and Fratzscher (2005, 5) have studied and compared the communication strategies of three central banks: the ECB, the Federal Reserve, and the Bank of England. Additionally, Ehrmann et al. (2007, 511) and Rosa and Verga (2007, 147) have found out that the tone of central banks' announcements may explain to some extent returns of financial assets. It would be interesting to study the impact of each unconventional monetary policy tool on security prices separately and to compare the effectiveness and magnitude of each policy measure. Also, comparing the impact of the monetary policy on security prices between business sectors and in other market areas would give a new perspective on the topic. Additionally, the information could be helpful for example for investors when diversifying portfolios as the impact of the policy actions on securities may differ between sectors and economic areas. Going deeper into stock markets, the influence

of the policy actions on different kinds of stocks such as value versus growth stocks would be interesting since the stocks may react differently to the policy announcements. Also, effects of the monetary policy to other securities such as bonds could be researched. Furthermore, the extent of the effects on bonds of different maturities could be compared. Due to the transmission mechanism of the monetary policy, it could be expected that bonds of shorter maturities would react stronger to the monetary policy shocks than bonds with longer maturities.

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Appendix 1. The ECB Governing Council meetings 2009-2019 (Rogers et al. 2014, 761-762, European Central Bank 2022c)

Year	Date	Monetary policy announcement
2009	15 January	MRO rate decreased to 2.00 %
	5 February	
	5 March	MRO rate decreased to 1.50 %
	2 April	MRO rate decreased to 1.25 %
	7 May	three 1-year LTROs, CBPP
	4 June	CBPP details announced
	2 July	
	6 August	
	3 September	
	8 October	
	5 November	
	3 December	Phasing out of 6-month LTROs, indexation of 1-year LTROs
2010	14 January	
	4 February	
	4 March	Phasing out of 3-month LTROs, indexation of 6-month LTROs
	8 April	
	6 May	
	10 June	
	8 July	
	5 August	
	2 September	
	7 October	
	4 November	
	2 December	
2011	13 January	
	3 February	
	3 March	FRFA extended to July 2011
	7 April	MRO rate increased to 1.25 %
	5 May	
	9 June	
	7 July	MRO rate increased to 1.50 %
	4 August	SMP covers Spain and Italy
	8 September	
	6 October	CBPP2 launched
	3 November	MRO decreased to 1.25 %

	8 December	Two 3-year LTROs, reserve ratio to 1 %, MRO rate decreased to 1.00 %
2012	12 January	
	9 February	ECB approved criteria of credit claims for 7 NCBs
	8 March	
	4 April	
	3 May	
	6 June	
	5 July	MRO rate decreased to 0.75 %, deposit facility rate to 0
	2 August	Outright Monetary Transactions programme
	6 September	OMT details released, no ex-ante size limit
	4 October	
	8 November	
	6 December	
2013	10 January	
	7 February	
	7 March	
	4 April	
	2 May	MRO rate decreased to 0.50 %, FRFA extended to July 2014
	6 June	
	4 July	
	1 August	
	5 September	
	2 October	
	7 November	MRO rate decreased to 0.25 %, marginal lending facility decreased to 0.75 %
	5 December	
2014	9 January	
	6 February	
	6 March	
	3 April	
	8 May	
	5 June	MRO rate decreased to 0.15 %, marginal lending facility decreased to 0.40 %, rate on the deposit facility decreased to -0.10 %
	3 July	
	7 August	
	4 September	MRO rate decreased to 0.05 %, marginal lending facility decreased to 0.30 %, rate on the deposit facility decreased to -0.20 %
	2 October	
	6 November	
	4 December	
2015	22 January	

	5 March	
	15 April	
	3 June	
	16 July	
	3 September	
	22 October	
	3 December	Rate on the deposit facility decreased to -0.30 %
2016	21 January	
	10 March	MRO rate decreased to 0.00 %, marginal lending facility decreased to 0.25 %, rate on the deposit facility decreased to -0.40 %, monthly purchases under APP expanded to 80 billion euros starting in April 2016, four 4-year TLTROs launching starts in June 2016
	21 April	CSPP details announced
	2 June	More CSPP details announced
	21 July	Forward guidance on interest rates, more details on APP
	8 September	
	20 October	
	8 December	Monthly asset purchases will decrease to 60 billion euros starting in April 2017
2017	19 January	
	9 March	
	27 April	
	8 June	
	20 July	
	7 September	
	26 October	Monthly asset purchases will decrease to 30 billion euros starting in January 2018, ECB reinvests principal payments from maturing securities under APP, 3-month LTROs will be conducted as fixed rate tender procedures
	14 December	
2018	25 January	
	8 March	
	26 April	
	14 June	Monthly asset purchases are planned to be decreased to 15 billion euros starting in September 2018, forward guidance on interest rates
	26 July	
	13 September	
	25 October	
	13 December	APP will end in December 2018
2019	24 January	
	7 March	Forward guidance on interest rates, TLTRO3 will be launched in September 2019
	10 April	

	6 June	TLTRO3 details announced
	25 July	Forward guidance
	12 September	Rate on the deposit facility decreased to -0.50 %, APP will relaunch starting in November 2019 at monthly pace of 20 billion euros, more details on TLTRO3, two-tier system for reserve remuneration
	24 October	
	12 December	

Appendix 2. Regression analysis results

Source	SS	df	MS	Number of obs	=	112
				F(2, 109)	=	63.12
Model	.024950724	2	.012475362	Prob > F	=	0.0000
Residual	.021543308	109	.000197645	R-squared	=	0.5366
				Adj R-squared	=	0.5281
Total	.046494032	111	.000418865	Root MSE	=	.01406

ret_banks	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
unexpected	-.0758792	.0129112	-5.88	0.000	-.1014688	-.0502897
ret_world_ex_europe	1.068388	.1260087	8.48	0.000	.8186432	1.318133
_cons	-1.069405	.1262319	-8.47	0.000	-1.319592	-.8192174

Appendix 3. Effect sizes test

Effect sizes for linear models

Source	Eta-squared	df	[95% conf.	interval]
Model	**.5366436**	**2**	**.4035058**	**.6242865**
unexpected	**.2406263**	**1**	**.1127694**	**.364234**
ret_world_ex_europe	**.3974177**	**1**	**.257496**	**.5088273**

Note: Eta-squared values for individual model terms are partial.

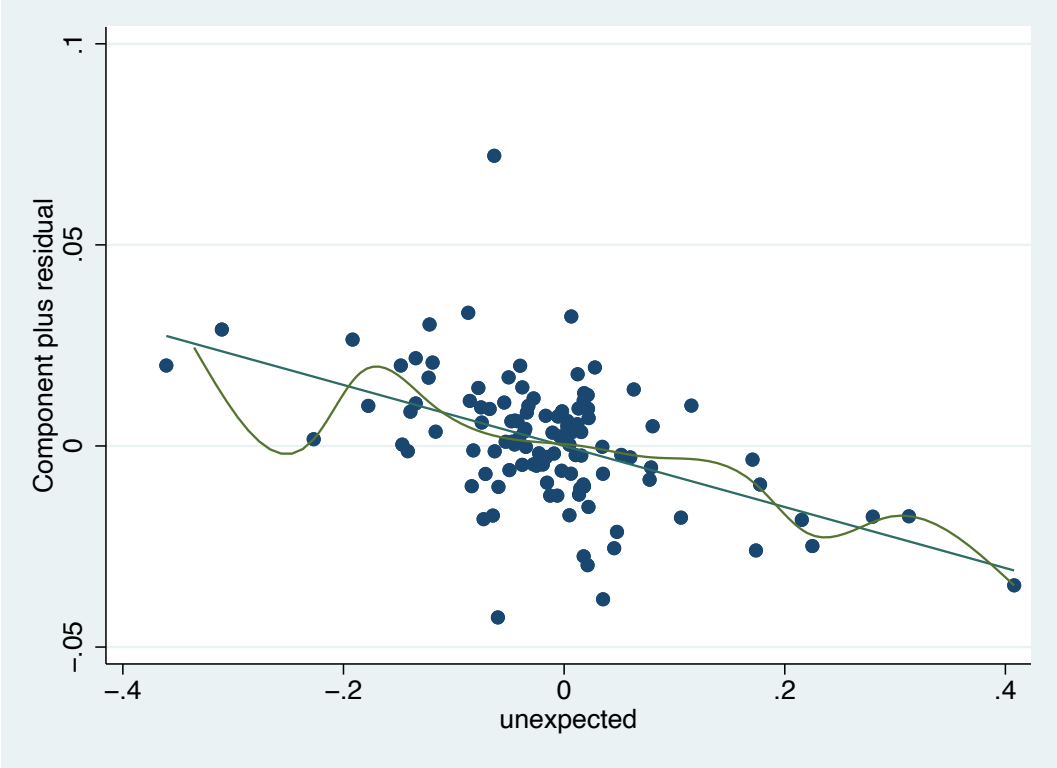
Appendix 4. Partial and semipartial correlations

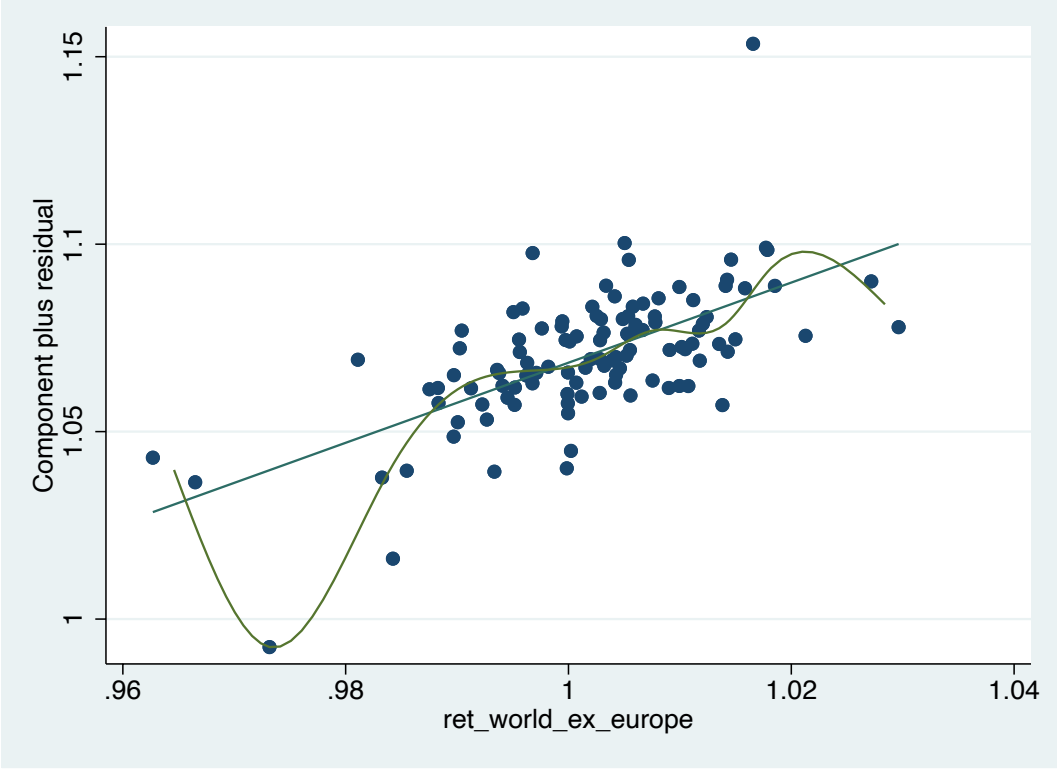
(obs=112)

Partial and semipartial correlations of ret_banks with

Variable	Partial corr.	Semipartial corr.	Partial corr.^2	Semipartial corr.^2	Significance value
unexpected	**-0.4905**	**-0.3832**	**0.2406**	**0.1468**	**0.0000**
ret_world~e	**0.6304**	**0.5528**	**0.3974**	**0.3056**	**0.0000**

Appendix 5. Component-plus-residual plots





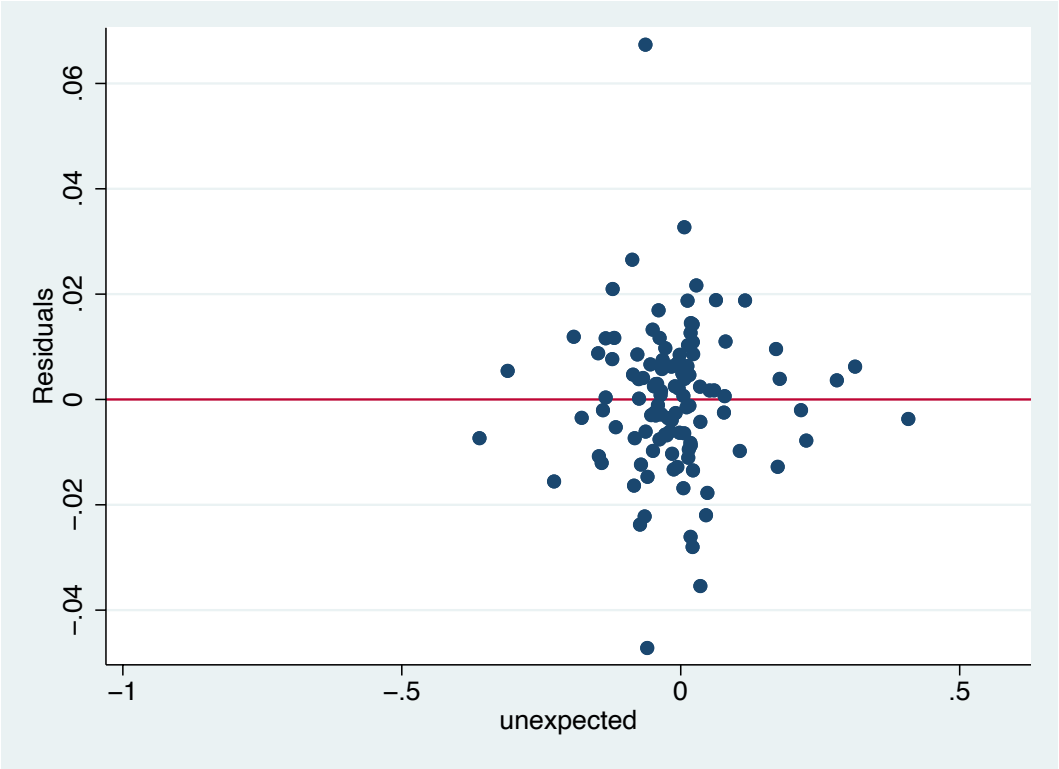
Appendix 6. RESET test

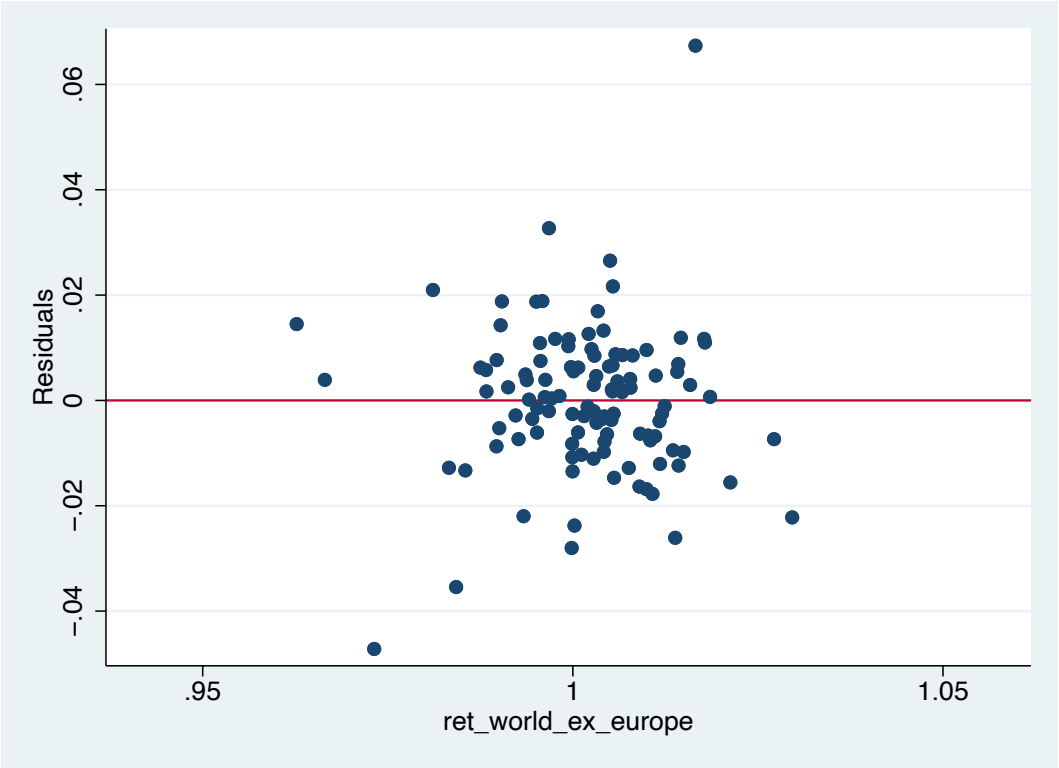
```
Ramsey RESET test for omitted variables
Omitted: Powers of fitted values of ret_banks

H0: Model has no omitted variables

F(3, 106) =   0.61
 Prob > F = 0.6077
```

Appendix 7. Residual-versus-predictor plots





Appendix 8. Breusch-Pagan and White tests for homoscedasticity

```
Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of ret_banks

H0: Constant variance

    chi2(1) =   0.02
Prob > chi2 = 0.8805
```

```
White's test
H0: Homoskedasticity
Ha: Unrestricted heteroskedasticity

    chi2(5) =   6.34
Prob > chi2 = 0.2749
```

```
Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	6.34	5	0.2749
Skewness	6.03	2	0.0489
Kurtosis	1.62	1	0.2025
Total	14.00	8	0.0819

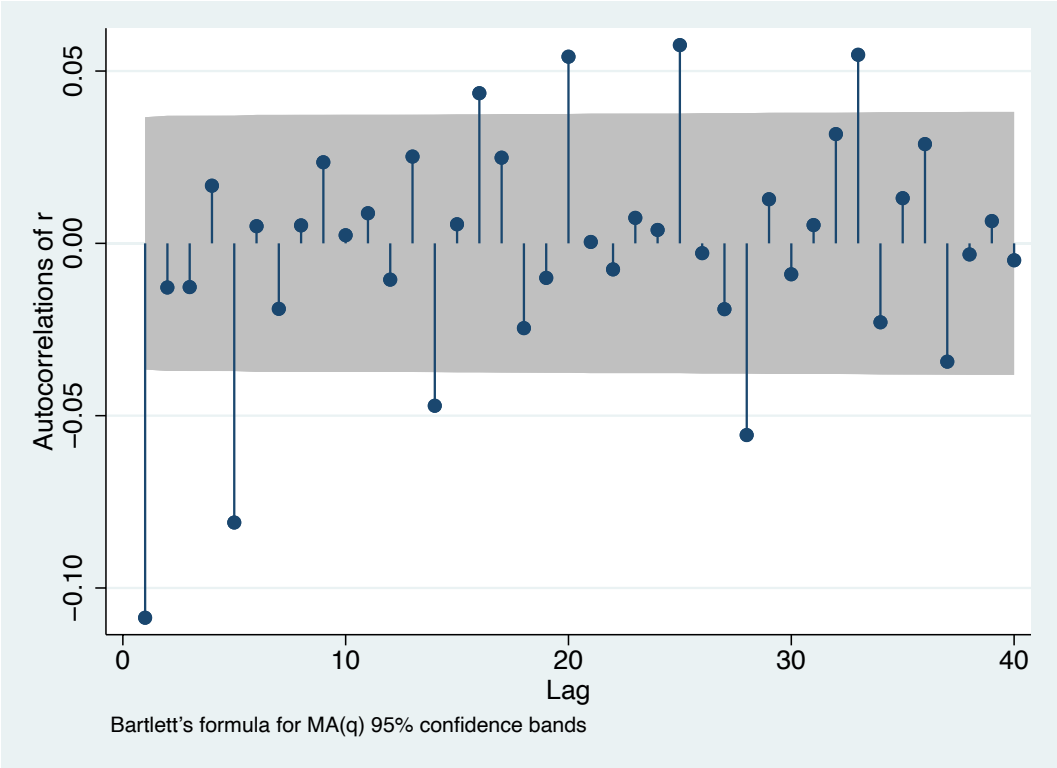
Appendix 9. Breusch-Godfrey test and correlogram of residuals

Number of gaps in sample = **111**

Breusch–Godfrey LM test for autocorrelation

lags(*p*)	chi2	df	Prob > chi2
1	**0.000**	**1**	**1.0000**

H0: no serial correlation

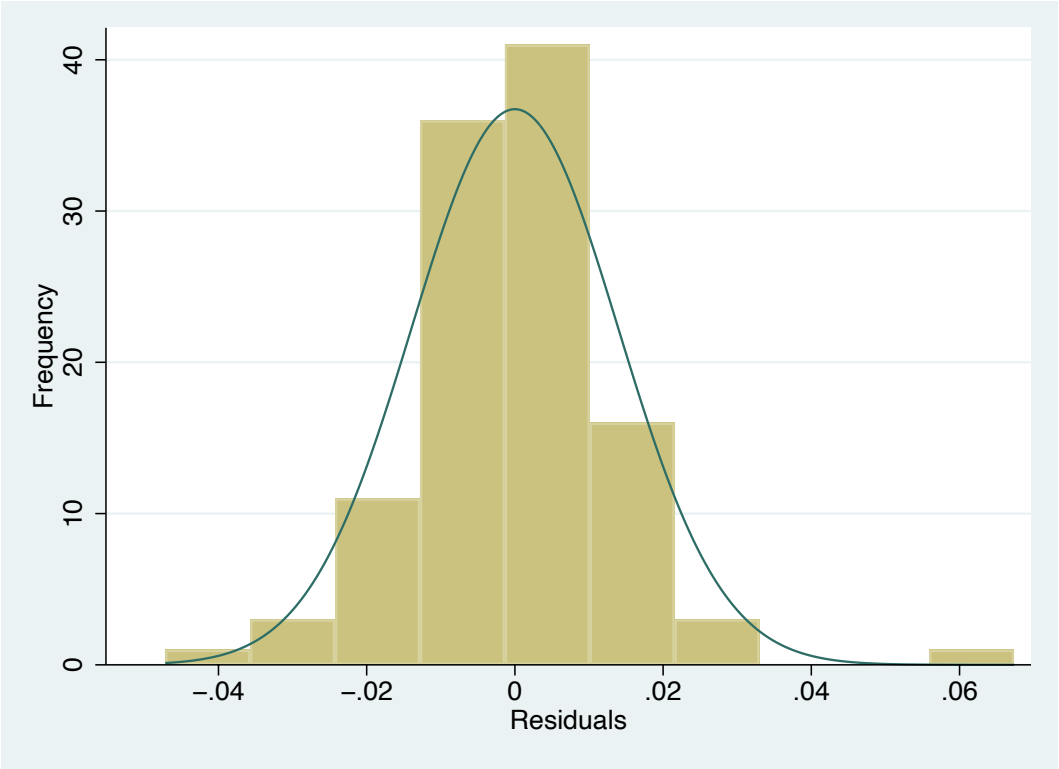


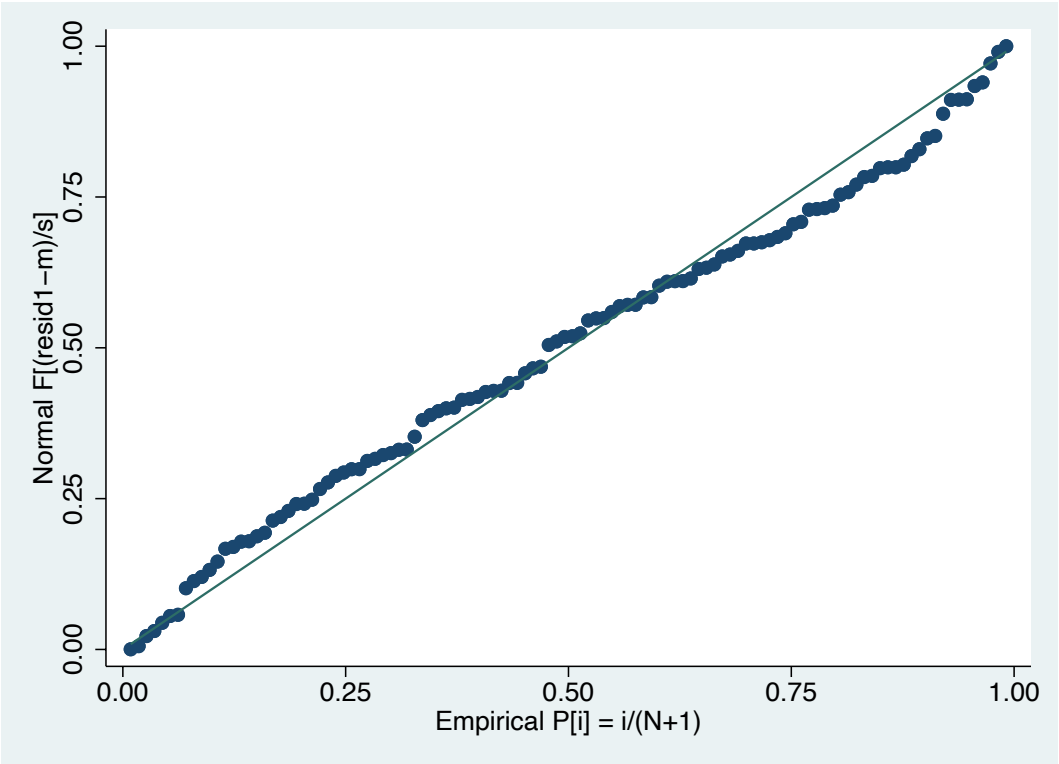
Appendix 10. Correlation between independent variables and VIF test

	unexpe~d	ret_wo~e
unexpected	**1.0000**	
ret_world_~e	**-0.1645**	**1.0000**

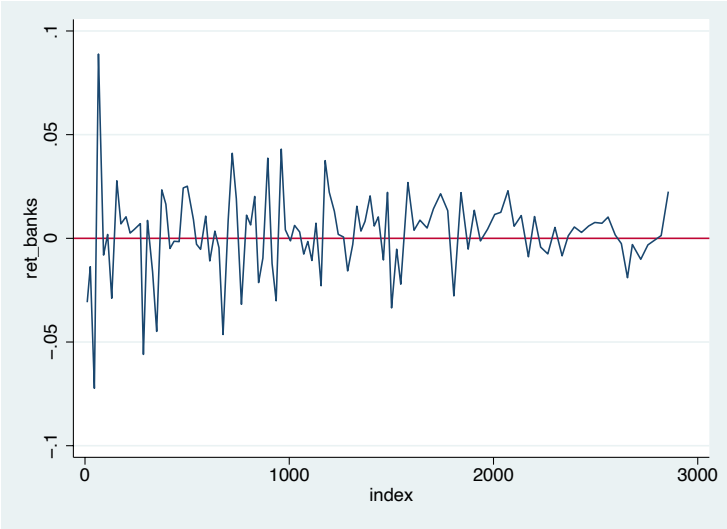
Variable	VIF	1/VIF
ret_world_~e	**1.03**	**0.972934**
unexpected	**1.03**	**0.972934**
Mean VIF	**1.03**	

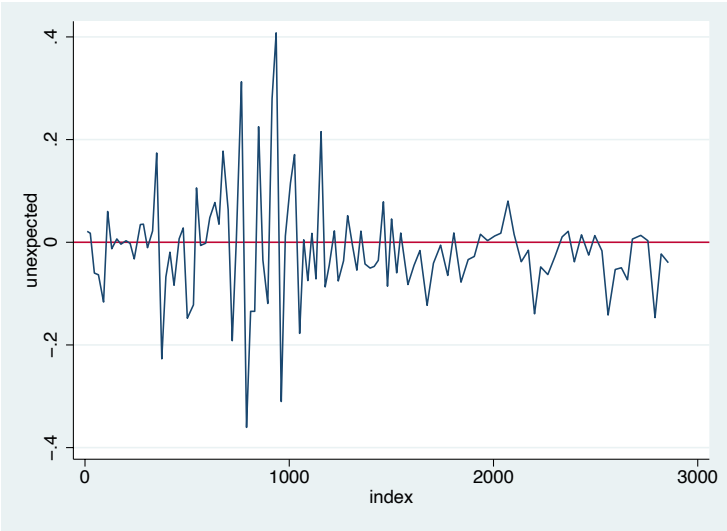
Appendix 11. Histogram of residuals and normal probability plot

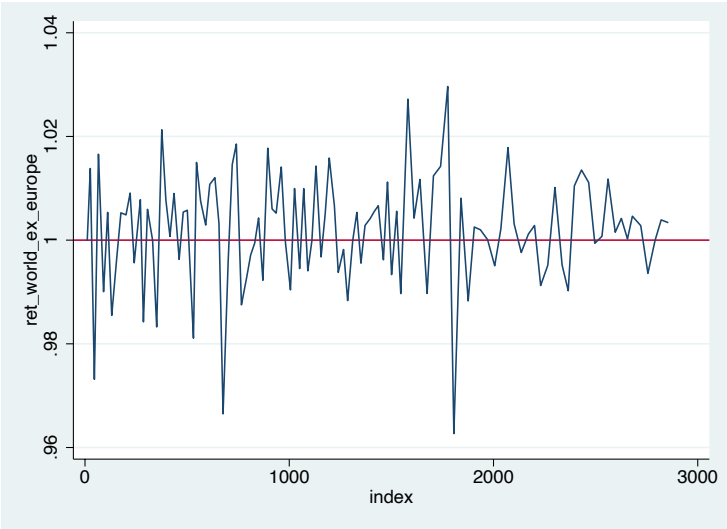




Appendix 12. Line plots of variables versus time







Appendix 13. Spike graphs of influence of observations