Abstract

The impact of monetary policy on financial markets has been the subject of much discussion and change in recent years. Central banks enact monetary policy which affects markets through several transmission channels, with commercial banks serving as the main agent. These channels have evolved in the past decade, with more relevance being given to unexpected or surprise announcements regarding monetary policy. This dissertation proves the existence of a significant relationship between unexpected European monetary policy and bank equities, by regressing the historic stock prices for six large European banks as a function of three separate variables representative of surprise monetary policy. These variables have been adapted as to reflect their daily variation, only on days of ECB policy announcements, as per official calendars, and consist of the 1-Month EONIA Swap rates, the 3-Month EURIBOR Futures and the spread between 2-Year German Government Bond yields and the 1-Month EONIA Swap rates. Main findings show that, while contractions in monetary policy produced significant increases in bank share market prices for all banks under scope, at some point in time before, during or after the financial crisis, results vary greatly by bank, with some banks seeing their shares severely impacted by unexpected changes in policy, while others are only slightly impacted. Temporal-based analysis reveal that the overall impact of unexpected policy on bank share price lowers considerably after the end of the financial crisis, reflecting new-era tendencies for transparency in central bank communication as well as bank's craving for financial structure and stability.

Keywords: Monetary Policy, ECB, Financial Markets, Share Market

JEL Classification: E58 – Central Banks and Their Policies

G1 – General Financial Markets

Resumo

O impacto da política monetária nos mercados financeiros tem sido objeto de muita discussão, nos últimos anos. Os bancos centrais introduzem medidas de política monetária que afetam os mercados através de vários canais de transmissão. Estes canais evoluíram na última década, enfatizando o papel de comunicados inesperados/surpreendentes, de medidas de política monetária. Esta dissertação prova a existência de uma relação significativa entre política monetária europeia de caráter inesperada e ações de bancos, recorrendo à regressão linear de preços históricos de ações de seis bancos europeus, em função de três variáveis distintas, representativas de política monetária inesperada. Estas variáveis foram adaptadas para refletirem apenas a sua variação diária, em dias de comunicações de política monetária por parte do BCE, conforme calendarização oficial, consistindo dos *Swaps* sobre a EONIA com maturidade 1 mês, dos Futuros de 3 meses sobre a EURIBOR e do *spread* refletido nas *yields* das Obrigações do Tesouro Alemãs a 2 anos. As conclusões principais demonstram que contrações na política monetária produzem incrementos significantes no preço das ações de todos os bancos estudados, num dado período de tempo antes, durante ou após a crise financeira, porém os resultados variam consideravelmente entre cada banco, sendo que alguns notam grande impacto no preço das suas ações, enquanto que em outros este é apenas ligeiro. Uma análise periódica revela que o impacto diminui consideravelmente após o término da crise financeira, refletindo novas tendências de transparência na comunicação dos bancos centrais, bem como a procura constante, por parte dos bancos, de solidez financeira.

Palavras-chave: Política Monetária, BCE, Mercados Financeiros, Mercados de Ações

Index

List of Graphics

List of Tables

1. Introduction

Monetary policy is a process utilized by central banks to establish some degree of control over macroeconomic indicators such as inflation and unemployment. However, the most immediate impact of policy actions is not on these variables, but on financial markets. central banks try to alter investor and consumer behavior with changes in official policy rates, which directly affects asset prices and performance. The purpose of this dissertation is to study the effects of European monetary policy on bank equity returns and the underlying relationship between the two.

Research on the topic suggests that there are several channels through which changes in official monetary policy impact equity markets, among them direct changes to the value of investor portfolios and to the general cost of borrowing. While these constitute more conventional channels which are still key factors in establishing the relationship between monetary policy and equity markets, new and unexpected channels have gained a surge in popularity over recent years, focusing on aspects such as the importance of central bank communication and transparency in the announcements of official policy changes. This has led to a definitive increase in the relevance of unexpected or "surprise" monetary policy decisions, which cause equity markets to react more significantly.

As such, this dissertation's goal is to narrow the spectrum of the relationship between monetary policy and equity prices by focusing on unexpected policy decisions and bank equities, characterizing the existing relationship between the two and whether there are significant differences in the connection, by distinguishing financial institutions from common equities. Monetary policy decisions conducted by the European Central Bank (ECB) in the past few years have been subject to much discussion and criticism as to their impact in financial markets. Such has been recently evidenced by the decision of the United Kingdom to leave the European Union (called *Brexit*). German officials, among others, have pointed the finger alleging said policies to hinder market growth and stability and high-ranking members of several financial institutions have even claimed that changes in European monetary policy have been one of the main contributors to poor results and meager bank performance.

The goal of this dissertation is achieved by compiling a sample of historical data regarding share prices for six European banks, as well as three distinct variables which comprise the surprise element of monetary policy. The variables representing distinct monetary policy instruments are constructed considering their overall role in the enactment of monetary policy, as well as dates of policy announcements. Time-series data ranging from 2002 until 2016 are then constructed for each variable, allowing for the comparison of the impacts before and after the financial crisis.

A study of existing literature on the subject and characterization of the relationship between monetary policy and bank equities can be consulted in chapter 2 – Literature Review, followed by a rationale for the choice of each element utilized in portraying both sides in chapter 3- Data Description. A deconstruction of the general topic the dissertation aims to establish is then transformed into quantifiable terms and testable hypothesis, the walkthrough of which can be seen in chapter 4 – Hypothesis. The hypothesis intends to specifically relate bank share prices and unexpected monetary policy, for which quantitative models are established in chapter 5 – Methodology, where the procedural methods conducted in order to test and prove the hypothesis and ascertain as to the relationship between bank share prices and monetary policy are exposed. The results are then revealed and interpreted in Chapter 6 – Presentation and Analysis of Results, where they are detailed by individual banks. A temporal breakdown analysis is also conducted comparing results for time periods before, during and after the financial crisis. A summary of the dissertation's main achievements and deductions is then exposed in Chapter 7 – Conclusion. Several other chapters act as support for the dissertation's efforts, such as Chapter 8 – References, where the bibliographical publications consulted are listed and Chapter 9 – Appendix, where all graphical representation and methodological outputs can be consulted.

2. Literature Review

2.1. Monetary Policy

Monetary policy is a term used to describe the range of macroeconomic strategies and plans laid down by central banks. As money can affect a considerable number of economic variables, and the overall well-being of a country, politicians and policymakers have an interest in managing money and interest rates – thus conducting monetary policy (Mishkin, 2004). The main goal of central banks utilizing monetary policy is to bring a certain macroeconomic variable such as inflation, unemployment, output or national income, closer to the desired value.

Monetary policy is directly related with economic theory, as it affects aggregate supply and demand and is thus used to expand or contract monetary activity (Duffy, 2015). In practice, it sets the boundary regarding money supply and reserve requirements, as the central banks' main monetary policy tools.

2.2. Monetary Policy Transmission Channels

There are multiple ways in which the announcement and implementation of monetary policy impacts a given economy and respective markets – these are referred to as the monetary policy transmission channels. From the work of Ramey (1993), Hubbard (2000), Bernanke and Kuttner (2004), Ehrman and Fratzscher (2004), Hyun and Shin (2009), Vera (2012), Angeloni, Faia and Duca (2015), Fratzscher, Duca and Straub (2016) and Ma and Lin (2016), it is possible to identify and characterize these different channels.

The transmission channel often considered the most direct and traditional one, as described by Hubbard (2000) is the interest rate or "money" channel. This channel, albeit relying on several key assumptions[1], remains the simplest example of monetary policy interaction. To describe it, assume there are only two assets in the market (money and bonds). Upon a monetary contraction, the central bank reduces reserves, which in turn will cause banks to reduce the supply of deposits they offer to investors. As such, the investors or depositors' reaction should be to hold more bonds and less money in their

[1] There are four key assumptions as described by Hubbard (2000), among which it is relevant to note the ones which ascertain the central bank's ability to exert control over the supply of "outside money" as well as to affect real and nominal short-term interest rates, which in turn should affect long-term rates (prices do not adjust immediately).

portfolios. Under price rigidity, which means prices do not adjust immediately to their new long-run level after the change in the money supply, "*the fall in household money holdings represents a decline in real money balances*" (Hubbard (2000: 3). The bond interest rate then increases to restore balance, which logically raises the cost of capital for several investment activities and makes investors refrain from interest-sensitive opportunities, spending less on these types of financial products.

Dalla, Karpetis and Varelas (2014) provide insight as to the way the interest rate spread is influenced by the reserve requirements. The authors analyzed the effect of a change in the minimum required reserves on the spread between the loan and deposit equilibrium rates. Their findings brought to light differences regarding market dimension and characteristics, in this monetary policy transmission channel. It was found that in markets with large economies of scope, the effect is negative – i.e. an increase in the level of minimum required reserves results in a narrowing of the spread between the equilibrium loan and deposit rates. In the case of smaller or nonexistent economies of scope, the effect is reversed, albeit requiring further analysis. Ehrmann and Fratzscher (2004) found additional asymmetries regarding the money channel's effectiveness in the transmission of monetary policy, highlighting that firms related to cyclical and capital-intensive industries react more strongly to shocks as well as more financially constrained ones.

The second most evident channel of monetary policy transmission is the credit channel. Like the money view, the process of the credit channel stems from the central bank's decisions to alter either the real level of reserves, or reserve requirements, which affects commercial banks' ability to function. Ramey (1993: 2) adds "*it is not the method by which the central bank has an influence on real reserves, however, that distinguishes the money and credit views. Rather, it is the channel by which changes in reserves impinge on real activity that differs*".

In the credit or "lending" channel, monetary policy not only affects the supply of bank deposits (money view) but also the supply of loans. According to the combined research of Ramey (1993), Kashyap & Stein (1994) and Vera (2012), to characterize this transmission channel, let's drop the assumption, previously used in the money view, that nonmonetary assets are perfect substitutes[2]. This channel may work in two ways – via

[2] Tobin and Clower (1970), Brunner and Meltzer (1972), Diamond (1984), Bernanke and Blinder (1988) and Bernanke and Gertler (1989) elaborated on this subject, with earlier works arguing that real assets and

bank's balance sheets, under which an increase in interest rate would decrease the value of borrower's collateral, which would cause firm investment to reduce, or via a bank-lending credit channel. A reduction in the volume of reserves conducted by the central bank also lowers the supply of loans, which in turn means that costumers who depend on bank credit will spend less, thus causing aggregate demand to fall. Essentially, after a monetary policy shock, banks will find it inevitable to decrease their supply of loans, when unable to offset a loss in reserves (either through lowering the amount held in securities or increasing other liabilities). Interestingly enough, Ramey (1993) also proved and concluded that the money channel is significantly more important than the credit channel, although this finding proved to be losing strength over the years.

According to Vera (2012), the assumption that a monetary contraction decreases banks' loan supply (or the reverse regarding an expansion), thus affecting output, has changed. By estimating a recursive four-variable VAR model, the author achieves evidence that this reaction has become less dire, in a sense that the response of aggregate loans to shocks in monetary policy has decreased. This is attributed to the changes in the regulatory framework regarding commercial banks, as well as their portfolios, which have prompted consolidation and more stability.

Hubbard (2000) highlights differences regarding the impact of monetary policy in the credit view, under the assumption that the financial cost of borrowing is not the same for every borrower. The author points two sub-divisions of the credit channel, one considering financial constraints on borrowers, and another admitting the existence of bank-dependent borrowers. The first sub-channel allows for the transmission of monetary policy to occur "*even if open market operations have no direct effect on bank's ability to lend*" (Hubbard, 2000: 9), as policy increases to the real interest rate simultaneously aggravate the financial burden of debt-related services for firms while decreasing the present value of collateralized net worth. This, in turn, raises the cost of financing and hinders firm's investment possibilities. The other channel is directly related to the existence of borrowers which are completely dependent on bank financing. Essentially, if a monetary contraction drains bank reserves (as they are subject to reserve requirements on liabilities), banks might be unable to lend as much as they previously had, which means

financial assets were not perfect substitutes, with more recent research focusing on the divergence between different financial assets, derived from the presence of information asymmetries in financial markets.

that available credit to said bank-dependent borrowers will decrease, and their spending should drop.

Assuming a more quantitative stance regarding the lending channel, Kashyap, Stein et al (1994) find empirical evidence supporting the underlying theory of the credit channel, by testing the response of bank loans to shocks in monetary policy. However, the authors also find a clear separation in terms of bank size – that is, they find that a monetary policy contraction affects small banks more considerably than larger banks, which do not appear to feel the effects as fast or as seriously.

Regarding unstandardized monetary policy, Fratzscher, Duca and Straub (2016) have recently proposed four possible transmission channels for this type of policies. These include the confidence channel, which states that, by taking action and intervening in the economy with the use of monetary policy, central banks increase confidence in the financial system, which ought to materialize into a positive effect on asset prices, as it might decrease uncertainty and reduce risk premiums; and the bank credit risk channel, in which policies directed towards addressing liquidity concerns result in lower credit risk, decreasing risk premiums and therefore possibly increasing asset prices. The two remaining transmission channels pointed by the authors are the sovereign credit risk channel and the international portfolio balance channel, which are both related to the international spillover effect of monetary policy shocks.

2.3. Impact of Monetary Policy on Financial and Equity Markets

According to Bernanke & Kuttner (2004), "The most direct effects of monetary policy actions (…) are on the financial markets". Central banks, through policies that affect asset prices and returns, attempt to influence economic behavior according to their objectives. By using Federal Funds futures data to gauge expectations regarding US monetary policy, these same authors found that unanticipated rate cuts generate an almost immediate rise in equity prices, for broad stock indexes. They also note larger responses to policy changes that appear more permanent and differences across industrial sectors. A 25 basis point (b.p.) rate cut leads to an increase in stock prices of about 1%.

Ehrmann and Fratzscher (2004) build upon this, by looking at S&P500 returns on days of monetary policy announcements by the Federal Reserve, henceforth designated as Fed. They find that an unexpected tightening of 50 b.p. decreases US equity returns by 3% on the day of the decision. They also confirm the hypothesis that effects of monetary policy on equity markets are asymmetrical, as markets react more intensely when the policy decisions are unexpected, when they represent a directional change in the monetary policy trend and during periods of considerable equity market volatility. Industry-wise, the same authors also found that cyclical sectors have a two to three times stronger reaction than other sectors. Ehrmann and Fratzscher's contribution to the field also highlighted the influence of information asymmetry effects, between firms.

Several authors have also analyzed the effects of unstandardized monetary policy. By unstandardized monetary policy, one should refer to monetary policy instruments that derive from the usual and "standard" ones, but which are clearly introduced to enact policy. Rieth, Piffer and Hachula (2016) explored the reaction to announcements from the ECB regarding non-standard monetary policy on the European and German economies, finding that the 2Y bond-yield drops immediately, followed by a slight overshooting until re-stabilizing, in order to correct the effects of the surprise element. Such leads to a reduction in terms of uncertainty in financial markets. Curiously, they find the opposite phenomena in German economy, which sees its financial market grow upon this expansion (which the authors attribute to the flight-to-safety behavior). Fratzscher, Duca and Straub (2016) reach a similar conclusion, that non-standard monetary policy announcements in the euro area influenced markets worldwide by increasing investor's confidence (or decreasing their risk aversion). They expand upon this, comparing announcements from the Federal Reserve and the ECB and analyzing the possibility of international spillovers from non-standard monetary policy announcements. They find that while international portfolios don't appear to react very strongly to ECB announcements, US policy has a more meaningful impact, which they attribute to the fact that Fed announcements seem to be more perceived as market movers than ECB ones. Mamatzakis and Bermpei (2016) gauged that US bank's performance reacts negatively upon unconventional monetary policy announcements by the Fed.

To study the effects of monetary policy on a more detailed scale, the work of Sousa (2013) provides intel by looking at the case of a small open economy: Portugal. The author identifies monetary policy shocks (via the use of time-series models) and evaluates their impact on several internal and external macroeconomic variables, under the hypothesis that "*…monetary policy interventions may affect the nexus between monetary stability and financial stability*" (Sousa, 2013: 240). The model achieves this by using the interest rate as the monetary policy instrument, and the main results show that, upon a monetary policy contraction (i.e. a rise of about 25 b.p. in interest rate), real GDP falls significantly, while the unemployment rate rises; commodity prices fall rapidly, leading to a gradual decrease in price level; the stock price index reacts negatively, albeit showing signs of recovering at a reasonably fast pace and there is also "*...a short-lived liquidity effect*" (Sousa, 2013: 247), together with a flight-to-quality in asset portfolios. The VAR model utilized reveals that 8.9% of the variation in the stock price index can be explained by unexpected variation in monetary policy, as well as that shocks in the interest rate account for about 3.9% of the variation in the index (when looking 20 quarters ahead). A comparison with the euro area reveals that the effect of a monetary policy contraction on European stock price indexes is negative upon impact, while it is gradual in the Portuguese stock market.

2.4. Importance of Central Bank Communication

The ability to enact monetary policy and the effectiveness of central bank decisions has been a topic of study throughout many years, with many theoretical explanations being found by various experts. One underlying driving force pertains to the role that the manner in which decisions are announced/made available to the public plays in the impact of said monetary policy decisions, with publications from Guthrie and Wright (2000), Kleimeier and Sander (2003) and Filbien and Labondance (2009), among others, expanding on this unseen variable.

A publication by Guthrie and Wright (2000) provides an explanation detailing how statements from the central bank, aptly named "*Open Mouth Operations*", can be used to implement monetary policy and direct it. The authors found that, by analyzing the example of monetary policy implementation in New Zealand, interest rates move in the direction intended by the central bank, sometimes even in extreme cases when there are no open market operations – thus, in such cases, the simple announcement made by the central bank has the desired effect. The paper proposed by the authors "*presented a model of monetary policy implementation in which investors, acting in self-interest, force interest rates to the levels desired by the monetary authority. If interest rates move out of line with those required by the monetary authority, a statement (an open mouth operation) is all that is needed to restore them*".

Kleimeier and Sander (2003) introduce a distinction between expected and unexpected impulses in monetary policy, gauging how retail banking interest rates react to changes in monetary policy. Methodologically speaking, the authors define impulses in monetary policy as the conjunction of both its expected and unexpected components. Their main conclusion highlights the efficiency of monetary policy transmission channels when changes are anticipated, proving a faster response and pointing to the importance of the role of central bank communication, for monetary policy effectiveness.

An extensive working paper by Woodford (2005) takes a look at how central bank policy regarding communication of monetary policy-related decisions has increased in importance over the last 15 years and questions whether a more transparent approach has the desired effect on short-term interest rates. The author details several real-life examples of cases in which central banks made announcements to the public and the outcomes from the highlighted historical events. One of his main conclusions is that the increased willingness to speak openly about current and future monetary policy decisions greatly increases markets' ability to anticipate its effects, which in turn proves beneficial by reducing uncertainty regarding financial trade markets, as well as by keeping investor's expectations more in line with the central bank's, increasing the accuracy with which policy enactors are able to impact the economy.

The work of Andersson, Dille and Sellin (2006) provided insight and much-needed detail onto the relationship between central bank communication and the effectiveness of monetary policy, by analyzing the effect on the term structure of Swedish interest rates from a wide range of signals/announcements from the Riksbank, like inflation reports, speeches and minutes from monetary policy-related meetings. The authors highlight the importance of alternative monetary policy transmission channels, looking beyond the "standard" existing channels and among their findings perhaps the most interesting is the conclusion that unexpected signals derived from speeches pertaining to monetary policy generate larger effects on official interest rates than unexpected changes in the interest rate. By broadening the scope of central bank actions regarding monetary policy, the authors could ascertain as to the importance of the role that central bank communication plays, in various shapes and forms.

On the other hand, by analyzing the response of European stock markets to unexpected ECB monetary policy announcements, Filbien and Labondance (2009) find that

"*...results show that very few ECB's announcements are unexpected by ECB watchers, this is a sign that the ECB's monetary policy is very predictable"*. They measure the unexpected/surprise component of monetary policy by analyzing press coverage days before the announcement of unexpected ECB decisions, regarding monetary policy.

Sebestyén and Sicilia (2005) distinguish three types of official ECB communication tools: Introductory Statements from meetings of the Governing Council, which are made available immediately; Declarations from members of the Executive Board (with highlight to testimonies from the President) at the European Parliament, and speeches of Executive Board members. The authors test the impact that these external communication instruments generate, on money and debt markets, considering impacts both in level and in volatility, concluding that the most severe impact is verified in the level of all interest rates. Another significant conclusion achieved is that the afore-mentioned Introductory Statements are the communication instruments with the most noteworthy effect on markets, with statements provided immediately after rate-changing meetings causing excess volatility. Interestingly, the authors also note the presence of a clear change in the perception of monetary policy decisions, when the Governing Council switched from bi-monthly to monthly meetings (in November 2001), marking an increase in the degree of predictability and, to an extent, transparency.

It is also relevant to analyze the work of Pericoli and Veronese (2017), detailing the evolution of the impact surprises in monetary policy produce on financial markets, in the euro area and in the US, since 1999. The study stands out not only for using numerous event-based metrics generated from decisions and announcements made by the ECB and the Federal Reserve, but also by comparing the impact that surprise monetary policy produces across 3 periods of time – the pre-crisis period, ranging from 2000 until 2008, during the financial crisis from 2008 to 2012 and the post-crisis period since. Their findings support the hypothesis that much of the effect produced by surprise announcements regarding monetary policy before and during the crisis period is related to the climate of financial uncertainty regarding central banks and most importantly that the adoption of forward-looking measures and guidance by central banks in recent years drastically reduces the impact of surprises on equity price indices, among other indicators – "*The impact on equity price indices of a contractionary ECB surprise, while still negative and statistically significant on most markets, is much smaller than during the crisis period*".

3. Data Description

In order to propose a model relating bank equity prices and monetary policy, several data components are required. The process under which each of these components was elected is described below, in chapters 3.1 through 3.3.

3.1. Bank Equity Prices

The share price of financial institutions is arguably the most relevant variable this dissertation aims to model. As such, given our goal of relating bank equity prices and monetary policy, the process of collecting the necessary data underwent several requirements and specifications.

The choice of which financial institutions' equities to utilize was made with the goal of successfully representing the European banking industry. As such, a sample of share prices for 6 European banks of different characteristics was elected:

- HSBC Holdings PLC – Europe's largest bank (in amount of assets detained) and the world's sixth largest, it is a British banking and financial services holding company. Its total assets amount to over 2.374 trillion US dollars and it is present in 70 countries. Its primary stock market listings are on the Hong Kong Stock Exchange and the London Stock Exchange. Its dominant position in the European financial institution industry translates to its stock market valuation, with a market cap of approximately 131,225 million British Pounds.
- BNP Paribas – Formed through the merger of *Banque Nationale de Paris* and *Paribas*, this bank is the 2nd leading bank in the euro zone, working primarly through the main domestic markets of France, Belgium, Italy and Luxembourg. BNP Paribas is listed on the First Market of Euronext Paris and its current valuation exceeds 74,807 million Euros.
- Deutsche Bank AG – This German financial services institution has been a reference for over 140 years in the European banking industry with total assets exceeding €1.5 trillion. However, in recent years the bank has seen significant losses and has been subject to restructuration procedures, reporting a net loss of approximately €6.7 billion in its 2015 activities, leading to a required capital increase in 2016. It is valued with a market cap of approximately 32.22 billion euros and traded in the Frankfurt and New York Stock Exchanges.

- Banco Santander – This Spanish banking group has expanded its operations worldwide since the 2000's, albeit being present in the Spanish market for over 160 years. Its total assets amount to approximately €1.34 trillion with a profit in 2015 of over €6.5 trillion. It is traded in 7 different stock exchange markets, among them the *Bolsa de Madrid* as well as the London and New York Stock Exchanges, with a market capitalization of more than 84 million euros, as of April 2017.
- UniCredit – An Italian financial institution, with a strategic position in Western and Eastern Europe, it was founded in 1998 and total assets amount to approximately €859 million, with most of its growth and expansion strategy hinging on mergers and acquisitions of smaller financial institutions. After being subject to several ECB stress tests, the Bank announced a massive recapitalization of €13 billion, on the fourth quarter of 2016. Its shares are traded in the *Borsa Italiana*, as well as the Warsaw and Frankfurt stock exchanges, with a market cap of around €31 billion.
- UBS – This company was founded in 1862 in Switzerland, where it is the leading provider of retail and commercial banking services, managing over US$1,966 assets. It is traded in the Swiss Stock Exchange, as well as the New York Stock Exchange, with total assets amounting to around US$934 billion (as of 2015) and a market cap of about US$58.21 billion.

Regarding the period to which the collected data pertains, daily stock prices for the 6 afore-mentioned banks was collected, from the 1st January 2002 to 31st December 2016. The period was chosen as to consider the different periods through which financial markets showed significant characteristics – the pre-crisis, crisis and post-crisis periods. This way, it's possible to single out each bank's performance in a specific economic/financial conjuncture, by analyzing the 3 different time periods. By analyzing daily data for a total of 15 years, the pooled data amounts to over 3800 individual observations and should provide a clear picture of each financial institution's market performance over the years.

The daily historical stock prices for the chosen banks was collected from Bloomberg, as this is the most globally-known and reliable service available and there were no shortages in data or periodic fails – as such, all the desired components regarding bank equities were collected.

3.2. Monetary Policy Surprise Component

In order to quantify the impact of European monetary policy on stock markets and interested parties, several variables could be used as its main indicator. From the research compiled on the subject (refer to chapter 2. Literature Review), it is possible to ascertain that investor's reactions to monetary policy is more significant and noteworthy when faced with unexpected/surprise changes in monetary policy. As such, the pool of variables elected to quantify this component was compiled as to highlight this aspect.

The means through which it is possible to quantify the "unexpected" nature inherent to some monetary policy decisions has been the subject of discussion for many years, with several variables being used as *proxy* in proposed models.

While market-based measures attempt to quantify the "surprise" component of monetary policy through the use of daily changes in short rates, survey-based measures build upon the *gap* between market expectations and the actual decision.

The list of data and variables compiled, as well as a rationale behind the choice and role of each variable, is described below, in chapters 3.2.1 through 3.2.3.

3.2.1. 1-Month EONIA Swap Rates

The intent behind the choice of this variable is to find a type of data that reflects, as accurately as possible, investor's reactions to changes in monetary policy, derived from unexpected announcements. As such, the variable ought to reflect 2 distinct components: the influence of ECB decisions regarding monetary policy and the market's ability to react to them in a timely manner. Taking this into consideration, one of the variables proposed to reflect the "surprise" component of monetary policy is the Euro Over-Night Index Average (EONIA) Swap.

EONIA Swaps are among the most liquid financial instruments traded in the European markets and act as a benchmark character within the European money market derivative products segment, as their high daily volumes and liquidity are clear conductors of market trends and investor dispositions.

While the EONIA is a market rate, computed as the weighted average of all lending transactions in the European interbank market, an EONIA Swap is similar to an ordinary interest rate swap, as a payer or "buyer" in the transaction pays a fixed rate and receives a floating rate pegged to the daily EONIA.

On 20th June 2005, the EURIBOR ACI and the European Banking Federation (EBF) established the EONIA Swap Index, with the intent to stimulate the overnight index swap (OIS) market and create new products featuring the EONIA as underlying financial instrument. This Index arises as a complement to the range of existing benchmark indices, the EURIBOR and EUREPO, which pertain to the unsecured and secured cash markets, respectively. Similar to the indices referred, the EONIA Swap Index is the mid-market rate at which swap contracts over the EONIA are traded and is calculated daily on a 360 day count convention, per voluntary submissions from 25 European and international banks. The EONIA Swap Index was discontinued as of 1st July 2014, as the number of contributing banks consisted of only 8 at this date, upon which the EBF feared for the robustness and continuity of the index, electing to discontinue its usage.

As the Index's timespan is not enough to cover the desired period, daily data for EONIA Swap rates was utilized, as reported by Bloomberg from a compilation of data from several financial institutions, on days of monetary policy announcements from the ECB, between 01.01.2002 and 31.12.2016.

A list of all the monetary policy decisions, per year and date of publication, is available for consultation on the official ECB website[3], from which the concrete dates were extracted. On days of policy announcements, the daily variation of the EONIA Swap rate is taken, while on other days, a value of 0 is considered. Regarding maturity, the 1-Month rate is elected because it is the same length as that of the maintenance period, thus not being directly affected by banks' behavior regarding reserve requirements. This choice of variable has been widely used in the literature, with this procedure being further supported by Pericoli and Veronese (2017), as the elected variable to represent interest rate expectations in the euro-area interbank market.

[3] See hyperlink: https://www.ecb.europa.eu/press/govcdec/mopo/2002/html/index.en.html

3.2.2. 3-Month EURIBOR Futures Rates

Futures remain one of the most reliable financial derivatives to gauge investor's intents and expectations regarding future performance of an underlying asset. By resorting to future contracts over the 3-Month EURIBOR, it is possible to get a reading on what the market's expectation is, regarding the future path of short-term European interest rates.

This instrument consists of a cash settled future, for deposits with a 3-month maturity, based on the European Money Market Institute (EMMI) EURIBOR rate.

A time series is then constructed by subtracting the price of the future from the value of 100, as to generate the interest rate each future reflects. Similar to the EONIA Swap rates variable, the difference is then considered on days of monetary policy announcements, and 0 on the remaining days, as to highlight the surprise component.

Usage of the 3-Month EURIBOR Futures as a reliable measure for expected future spot interest rates is supported by Bernoth and von Hagen (2003), who conclude these rates to be unbiased and efficient predictors, being also applied by Kleimeier and Sander (2003) in their analysis.

3.2.3. Spread between German Government Bond Yields and EONIA Swap Rates

Shifts in the yield curves of government bonds are an accurate predictor of investor's intents and perceptions regarding the future paths of interest rates, as they are most often considered a "*safe haven*" financial instrument, to which investors resort to if they sense uncertainty in the markets.

Government bonds have been a staple device in research regarding monetary policy for several years. Thus, we resort to the spread between the 2-year German Bond yields and the 1-Month EONIA Swap rates, as a means of capturing the effects of surprise changes in monetary policy in investor predictions for medium-term European interest rates.

By taking the difference between the bond yields and the OIS rate, it becomes possible to quantify and highlight instances in which investors elected one instrument over the other. By considering the variation only on days of monetary policy announcements, it is possible to pinpoint the changes in monetary policy as the causing agent of said decision.

The daily yields were retrieved from Bloomberg, for the period considered (2002-2016). Afterwards, the 1-Month EONIA Swap Rate (OIS) was subtracted from the daily yields, from which was then taken the difference on days of policy announcements and 0 on other days.

The choice to take the spread between the 2-Year Government Bond Yield and the 1-Month OIS rate is proposed by Ferrari, Kearns and Schrimpf (2017), as a way of capturing the effect of monetary policy news on higher-maturity rates, via term premium effects (which the authors denominate "*path shock*").

4. Hypothesis

The main research problem of this dissertation, which is simultaneously its general hypothesis, is the existence of a clear and identifiable relationship between monetary policy and bank share prices.

As such, an initial or general hypothesis is proposed: “Surprise shifts in Monetary Policy have an impact on the Market Performance of European Banks”.

Refining this general statement into a hypothesis providing directionality on how to approach the research problem, a more precise and quantifiable hypothesis can be elaborated. As stated in chapter 3., surprise/unexpected changes in monetary policy are to be measured via the daily variations in EONIA Swaps, EURIBOR Futures and the spread between German Government Bond yields and the OIS, in days of policy announcements, while the market performance of banks is provided via their share price.

Translating the main research problem into a researchable/testable hypothesis, it is reasonable to build on an unexpected contraction in monetary policy, under which central banks aim to reduce the total level of money supply, signaled by an increase in official interest rates – thus, testing focus will hinge on a surprise policy rate increase.

It is anticipated that, for an unexpected tightening (contraction) in monetary policy, signaled by a surprise increase (decrease) in the policy rate, equity prices react negatively (positively). This effect can be explained in the following way: a share price reflects the present value of investor’s expectations regarding the company’s ability to generate future dividends (and revenue), discounted at the appropriate discount rate, which is affected by the afore-mentioned policy rate set by the ECB (that affects all interest rates in the economy). Contractionary policy is a type of policy used to fight inflation, under which central banks cause an increase in the cost of debt and a decrease in the GDP, thus restricting investor’s propensity to invest and overall spending, which in turn is a negative influence on expectations regarding company’s future performance. Additionally, a policy rate hike increases the discount rate at which equities are valued, thus decreasing it virtually instantly. Below is a visual aid, in the form of a simplified equation (1), to assist in understanding the impacts of a surprise policy rate increase:

$$P = \frac{D}{r} \quad (1)$$

P – Share price of a given company (the theoretical valuation based on dividends);

D – The expected dividend to be paid to shareholders during the next year;

r – Discount rate.

A surprise hike in the official policy rate would then, rationally, decrease share price (P) (the effects of the rate increase are represented with directional arrows in the equation above).

This effect is consistent with what has been researched on the subject (see chapter 2.4.), with unexpected policy rate increases decreasing prices not only for equity markets, but also for commodities, among other financial assets, with this directional effect being clearer in recent years. As such, this is the expected effect of contractionary monetary policy on bank equities this dissertation aims to observe. Although it is important to distinguish banks from common companies, as there are other monetary policy transmission channels at work (such as the money and the lending channels) when dealing with financial institutions, it is expected for the share prices to follow the directionality of other equities.

Resorting to the compiled variables which represent unexpected changes in monetary policy/official interest rates, a surprise increase in official central bank rates ought to generate a similar increase in the EONIA Swap rates, in the rates represented by the EURIBOR Futures and in the spread reflected in the yield of German Government Bonds and the OIS, as these instruments mirror, to an extent, the path of interest rates.

Gathering the assumptions described above, it is possible to define the following hypothesis, as subject to further testing:

> "Unexpected monetary policy contractions significantly decrease bank share prices. "

The afore-mentioned statement entails the specific hypothesis for which methodological efforts were conducted, to prove its authenticity. A monetary policy contraction is to be quantified and subject to further testing as a unitary percental point (pp) increase in interest rates.

The procedural methods conducted can be consulted in segment 5. “Methodology”, with the main results and subsequent analysis being present in chapter 6. “Presentation and analysis of Results”, in which the veracity of the hypothesis is assessed.

5. Methodology

Given that the goal of this dissertation is to relate bank share prices and monetary policy, in a way such as to prove that changes in monetary policy have a significant impact of bank's equities, an econometric model was created in order to achieve the desired goal.

In econometric terms, this dissertation aims to propose a model that generates evidence in how changes in monetary policy (quantified through the use of 3 distinct variables) have an impact on the share prices of banks. Thus, given the initial premise/hypothesis, the first stepping-stone hinges on a simple linear regression model.

5.1. Simple Linear Regression

In basic terms, a simple linear regression is an econometric model through which a dependent variable is related to a single other "independent" variable, which acts as explanatory variable in the model. Its purpose is to quantify and ascertain as to the impact the independent variable generates on the dependent one, through the analysis of their variations across different moments in time (in this case). Thus, the simple regression model is the best choice to achieve this dissertation's goal, as it allows us to model bank share prices (the "dependent" variable) as a function of each of the ECB's monetary policy effects (the "independent" or explanatory variables) and gauge each variable's impact and relevance, highlighting the connection between the two.

In order to increase the model's precision and reliability, as well as to deal with volatility issues that may arise, each independent variable is taken into consideration separately – thus, instead of having a Multiple Linear Regression Model (MLRM), a simple linear regression is run between each of the variables. Representing the cross-sectional data systematically:

$$Y_{i,t} = \beta_i X_t + \varepsilon_i \quad (2)$$

Y_i – The daily logarithmic returns from bank equity prices, for each of the 6 banks analyzed. The returns are derived from the daily stock prices, consisting in their daily variations from 01.01.2002 to 31.12.2016, from which is taken their logarithmic form and then multiplied by 100, as to allow for an easier and more logical interpretation;

β_i – Parameters or coefficients of the model (allow us to evaluate the impact of each explanatory variable on the dependent variable);

X_t – Daily variation on days of monetary policy announcements by the ECB (0 on the remaining dates) for each of the surprise policy measures:

- 1-Month EONIA Swap Rates;
- 3-Month EURIBOR Futures Rates;
- Spread between the 2-Year German Government Bond yield and the 1-Month EONIA Swap Rate;

ε_i – The Error term of the model, which represents the variation in the share price that is not associated with the variations in each of the explanatory variables.

Through the generated models and with the use of the simple linear regression model, it is possible to successfully establish a linear relationship between the dependent variable and the explanatory ones – that is, not only are we able to achieve evidence supporting that there is a causal relationship between monetary policy and bank share prices, but we are also able to estimate how the variation in each instrument of monetary policy impacts on the equities.

Thus, several different models, one for each of the banks selected for analysis, are proposed, to gauge the impact of monetary policy on bank equities. As the simple linear regression model requires several assumptions to be met, the various time series were handled accordingly, as to achieve the most adequate method and model. The econometric procedures conducted are described below.

5.2. Time Series Stationarity

As the model hinges on periodical returns of given stock prices, it is subject to issues that tend to placate similar time-series models. One of the most relevant conditions, or assumptions, upon which time series analysis is built on is the existence of a stationary process in the data. A time series deemed stationary is, in layman's terms, a series of data for which the mean and variance do not change over time (derived from the fact that its joint probability distribution does not change over time). The stationarity condition ensures that the analysis subject to the time series is reliable and that it is possible to estimate concrete parameters, which serve to derive conclusions from the use of said data.

Thus, the following step is to ascertain as to the stationarity of the share prices utilized in the analysis and verify whether there exists a trend in the time series and, if yes, which kind of trend. Typically, it is said that a time series has an underlying trend when there is a long-time increase or decrease in the data. The trend is a type of pattern often present in time series – examples of other patterns include seasonal or cyclical patterns. A time series may have a stochastic trend, when the variation is hardly predicted, albeit systematic (thus pointing to a non-stationary time series), or a deterministic trend, when the trend is entirely predictable. A graphical representation of each share price can be consulted in Appendix 9.1.

To effectively conclude regarding the stationarity of the time series, we resort to two different tests:

- The Augmented Dickey-Fuller (ADF) test, which assesses as to the presence of a unit root in the data. A unit root is, in generic terms, a feature of stochastic time series which generates problems regarding statistical inference from time series data, and
- The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, under which the null hypothesis is the stationarity of the time series, with the alternative being the presence of a unit root.

Evidence from both tests, the summary of which can be consulted in Appendix 9.2., suggests the presence of a stochastic trend regarding the plain daily share prices. As such, there is not yet a stationary behavior in the time series, as desired, suggesting the need to include additional components, or transform the time series, in order to deal with this specific volatility-related issue.

The outcome is the predictable one, as in common Finance theory, when dealing with share prices and similar market data, it is usual to work with the returns of share prices, rather than the actual levels, to avoid similar stationarity issues. As such, we compute the returns for each of the stocks (i.e. their daily variations), from which we take its natural logarithm, before applying a multiplier of 100 to the observations, as to assist in output interpretation (otherwise, output values would be several decimal places, which would not represent the data as accurately as possible).

The newly generated time series, nicknamed “DLOG”, proves to be stationary in nature, by re-running the ADF and KPSS tests, the results of which can be observed in Appendix

9.3. This means that by taking the daily logarithmic returns, instead of the actual stock prices, it was possible to stabilize the mean and variance, thus generating a stationary time series. A graphical representation of each variable can be consulted in Appendix 9.4. As such, this is the form under which the time series will be subject to further analysis and from which the intended models will be derived.

5.3. Modelling the time series

Having successfully generated a stationary time series, for each bank's stock prices, the goal is now to model said time series, as to generate a process under which statistical inference can be performed.

Therefore, it's possible to resort to the Autocorrelation (ACF) and Partial Autocorrelation (PACF) functions, as a means of proposing a model for the time series. The Autocorrelation function is a tool most often utilized to find patterns within a time series, providing the user with the correlation between points separated by several time lags (i.e. a delay between two observations in the data). Similarly, the Partial Autocorrelation function returns the partial autocorrelation between the values with shorter-lapsed time intervals, allowing for control of said values from a time series at all shorter lags.

Both the ACF and the PACF are useful in determining the parameters to be utilized in generating an Autoregressive Integrated Moving Average (or ARIMA) model. An ARIMA (p,d,q) is a generalization of an ARMA model (Autoregressive Moving Average) where an initial differencing step has been applied to eliminate the non-stationarity of the time series. The parameters p and q are, respectively, the number of lags of the autoregressive model (parameter of the PACF) and the order of the moving-average model (parameter of the ACF), with d being the order of differencing. As stock returns already take a first-order differencing step in their computation, it is not relevant to apply the d parameter in further analysis. As such, several ARMA models were then proposed, for each of the time series, with the elected ones being those in which all the estimates were statistically significant. In cases where more than one model's estimates are all statistically significant, the most adequate model was chosen by comparison of the Information Criteria (with the model presenting the lowest value being elected). While this is the correct process, econometrically, in economic terms the ARMA(1,1) model is the most widely-accepted as, when dealing with financial time series, it makes sense for the prices of a day to impact the share price on the next day, but not, for example, impact the share price 34 days from now.

As such, the ARMA(1,1) model was estimated for each of the time series or, in cases where the estimates were not statistically significant, similar specifications of the model were considered.

5.4. Volatility Measurement

The choice of the correct econometric process to model the time series should take into consideration each series' specificities and characteristics. To elect the most adequate model, an analysis of the residual or error component ought to be performed. The error/residual component pertaining to time series is a very reliable indicator of issues that may hinder the series' statistical inference power. Ideally, the residual component of a model follows a white noise process, i.e. a random process in which the observations are uncorrelated and with mean zero.

A common occurrence when working with financial time series is the presence of what is known as Autoregressive Conditional Heteroskedasticity or ARCH effect. In econometric terms, a time series has ARCH effect when the variance of the error term can be described as a function of the error term's previous observations. The presence of ARCH effect can be observed in a time series when there are periods in which the time series exhibits high volatility and periods of calm – this is known as time-varying volatility clustering. When an ARMA model has been assumed for the variance of the residuals, it is necessary to test for Generalized ARCH (GARCH) effect.

The easiest means of identifying the presence of GARCH effects is by testing whether there is correlation between the square residuals – while the residuals themselves might not show evidence of correlation, as is common when dealing with efficient stock returns, the squared residuals often prove to be strongly related, suggesting the presence of GARCH effects. As such, the correlogram of the residuals and squared residuals was generated for each time series. Interpretation of the Ljung-Box test (which tests for correlation between the values) reveals the presence of strong correlation between the squared residuals, pointing to the existence of GARCH effect.

To confirm the presence of an underlying GARCH effect in each of the models proposed, we resort to the Engle ARCH test, which establishes, in its null hypothesis, the absence of ARCH/GARCH effects. Results of the test can be seen in Appendix 9.5., and confirm the presence of GARCH effect, suggesting the need to resort to GARCH models as a means of stabilizing the variance.

There are multiple GARCH models which can be utilized to model the time series, while simultaneously dealing with the volatility issues described above. The consideration of which one proves the most correct is subject to the characteristics of each model and how accurate they are, in modeling the time series. While the ARCH(1) model is successful in modeling the conditional mean of the time series but is unable to deal with the non-constant variance, the GARCH(1,1) model allows the user to simultaneously model the variance and the mean of the time series. It is a symmetrical model, which means that a shock produces the same impact whether it's positive or negative. The TGARCH, or GJR, is an asymmetric model which models the standard deviation, instead of the variance and is achieved by adding a threshold component *t* to the GARCH(1,1). Lastly, the EGARCH is also an asymmetric model, which takes the logarithm of the conditional variance, thus ensuring that the resulting numerical estimation for the volatility is positive (which the other models cannot). As ordinary finance theory suggests that financial markets react more strongly to negative impacts than to positive ones, it makes sense to use one of the asymmetric GARCH models, for each of the time series.

The result of each econometric procedure served as the basis of choice for the most reliable ARMA-GARCH model for each share price, which can be observed, as well as a portrayal of main statistical elements for each of the time series in analysis, in the table present in Appendix 9.6.

The models described above were therefore generated and elected as the most adequate in assessing the impact of monetary policy on bank stock prices (the goal of the present dissertation). A linear regression was run for each of the share prices and each of the explanatory variables (as exposed in 5.1.), the outputs of which served as the basis for all drawn conclusions, which can be seen in chapter 6.

Additionally, as to discriminate and compare the effects generated by each explanatory variable on the share prices before, during and after the crisis, an intra-sample analysis was run for each regression, considering only certain periods of time, as opposed to the entire sample duration. The pre-crisis period was defined[4] from 01.01.2002 (first sample observation) to 31.10.2008, with the crisis period following from 01.11.2008 until 31.12.2012 and the post-crisis period between 01.01.2013 and 31.12.2016.

[4] The specification of dates for the 3 periods subject to analysis followed the denomination by Pericoli and Veronese (2017), with the date for the introduction of the Quantitative Easing program in the US marking the beginning of the crisis and official central bank announcements marking its end.

6. Presentation and Analysis of Results

Through the use of the specific econometric models described in chapter 5., by regressing the stock prices of each bank as a function of the different variables representing surprise/unexpected monetary policy, it became possible to quantify the existing relation between the two. In the following paragraphs, a presentation of relevant results and main findings can be observed, regarding the influence of surprise monetary policy on each of the six banks subject to testing, before, during and after the crisis period.

6.1. Presentation of specific/individual results per bank

Regarding the presentation of specific results, traditional econometric measures related to Linear Regressive Models are the methodological outputs presented, which allow for interpretation of results. The highlighted measures subject to interpretation are the following:

- Regression coefficients or parameters of the model (β_i), which quantify the impact that a unitary increase in the independent variable generates on the dependent one – that is, how much a unitary percentage point (pp) increase in the rate reflected by the unexpected monetary policy component produces on the bank's stock;
- T-test statistic, which is conducted to test hypothesis on the regression coefficients, more specifically, that the coefficient is null and there is no quantifiable impact, thus no impact produced by the independent variable on the dependent one, as well as its *p*-value – a 95% confidence level will be considered, unless stated otherwise, throughout the analysis.

Additional information and results pertaining to the simple linear regression measures are discriminated in Appendix 9.7. From the list of measures generated, it is important to clarify why the Adjusted R-Squared (R^2) is not subject to interpretation. The measure typically translates how much of the variance of the dependent variable is predictable from the independent one and the overall explanatory power of the model. However, the values assumed by it range between 0 and 2 percent, which is a direct consequence of utilizing only the values on days of monetary policy announcements for the dependent variables and 0 on other days, thus producing very low levels for the coefficient of determination. As such, this statistical measure is nigh insignificant, thus being unable to assist in the process of analysis, so it is merely present for observational purposes.

6.1.1. Deutsche Bank

Observing the entire period of 2002-2016, the 1-Month EONIA Swap Rate is the variable with the strongest explanatory power and influence over Deutsche Bank's stock price. There is a clear correlation between the two variables, with a p-value of 0.0061, significant at a 95% confidence level. When the daily variation in the 1-Month EONIA Swap Rate increases by 1 pp, the bank's share price increases by approximately 12.38%. Such means that an unexpected change in monetary policy, signaled by an increase in the Swap Rate, causes financial markets to appreciate Deutsche Bank's stock.

The 3-Month EURIBOR Futures, as well as the spread between the German Government Bond yields and the 1-Month OIS, do not exhibit a significant relationship with the historic stock prices, with p-values of 0.2474 and 0.8260, respectively. As such, only the EONIA Swap Rates appear to have a clear relationship with Deutsche Bank's stock price, when considering the full period between 2002 and 2016.

Splitting the sample into pre-crisis, crisis and post-crisis periods provides additional insight into the influence of each variable on Deutsche Bank's share price. While the influence of the Futures remains insignificant throughout each period (albeit slightly more during the crisis period), the explanatory relevance of the 1-Month EONIA Swaps appears to decrease overtime –the regression produced a p-value significant only before the crisis, of 0.0489, increasing to 0.1099 during the crisis of 2008-2012, after which it rose to 0.7859. Interestingly, the significance of this variable appears to have inverted with the significance of the spread between the Bond yields and the OIS, which shows a steep increase in significance throughout the years, with p-values of 0.8213, 0.1447 and 0.0232 for the pre-crisis, crisis and post-crisis periods respectively. The coefficient of regression for the latter period suggests that, upon a single pp widening of the spread between the two, Deutsche Bank's share price decreases by a significant 18.70%.

This evidence would suggest that the influence that surprises in monetary policy produce on Deutsche Bank's share price has been changing considerably in recent years, with investors reacting to surprise rate changes by steering away from the stock and valuing fixed-income assets, which might offer some more stable term premiums.

6.1.2. BNP Paribas

Regressing BNP Paribas' historical stock price as a function of each explanatory variable reveals that, similarly to Deutshe Bank, only the 1-Month EONIA Swap Rate appears to generate a significant impact on the time series, when considering the entire sample period of 2002-2016.

An increase of 1 pp in the daily variation of the 1-Month EONIA Swap Rate generates a positive impact on the share price, increasing it by about 9.85%. The regression returns a p-value of 0.0123, significant at the 95% confidence level.

Both remaining measures of monetary policy surprises (the 3-Month EURIBOR Futures and the spread between the 2-Year German Government Bond yields and the 1-Month OIS) do not reveal a significant impact on the share price, with respective p-values of 0.1787 and 0.8407.

The periodical breakdown of the regressions reveals that the explanatory power of the variables over BNP Paribas' share prices have been increasing overtime. While the EURIBOR Futures remains non-significant throughout the 3 time periods, the post-crisis era saw a drastic increase in significance from surprise changes in monetary policy signalled by the EONIA Swaps and, most surprisingly, by the spread in Government Bond yields. P-values after the crisis for each variable are of, respectively, 0.0267 and 0.0252, highly significant at the 95% confidence level. The impact of a unitary pp increase in the variables on BNP Paribas' stock is similar as well, with the Swaps effectively decreasing share price by about 23.06%, while the spread in the Bond yields decreases it by approximately 15.88%.

6.1.3. HSBC

Unlike the cases of Deutsche Bank and BNP Paribas, regressing HSBC's historical share prices as a function of each variable reveals that out of the measures utilizes to represent surprise monetary policy, both the 3-Month EURIBOR Futures and the spread between the 2-Year German Government Bond yields and the 1-Month OIS are significant in explaining the time series, with only the 1-Month EONIA Swaps failing to achieve this goal successfully.

An increase of 1 pp in the daily variation of the rate represented by the 3-Month EURIBOR Futures increases HSBC's stock price by approximately 5.91%, exhibiting a p-value of 0.0099, significant at the 95% confidence level. An identical increase in the daily variation of the spread between the Bond yields and the OIS returns a p-value of 0.0034, significant at the same confidence level, while increasing the share price by about 3.68%.

Regarding the crisis breakdown analysis, the same trend is present with the EURIBOR Futures, the significance of which increases considerably after the crisis, albeit showing a coefficient p-value of 0.0583, only significant when considering a hypothetical 90% confidence level, suggesting that in recent years, an increase of 1 pp in the variable produces a rise in HSBC's share price of approximately 13.33%. However, the significance of the spread in the Bond yields dramatically decreases over time, going from 0.0142 pre-crisis, to a mere 0.9096 post-crisis.

It is interesting to note that, while in the afore-mentioned banks that were subject to the same analysis, impacts of unexpected monetary policy showed an increasing trend overtime, suggesting financial markets became less resilient in their reactions to surprise announcements, HSBC's shares revealed the opposite – while before the financial crisis the bank's stock presented some volatility as a result of surprise changes, measured by each of the 3 variables, after the crisis the impact decreased, with the stock showing a certain degree of imperviousness to surprise changes in policy, in recent periods.

6.1.4. Santander

Santander Bank's stock shows correlation with surprise changes in monetary policy only regarding the spread between the 2-Year German Bond yields and the 1-Month OIS. Outputs from the simple linear regression of each of the 3 variables support this finding. The spread in the Bond yields returns a p-value of 0.0192, with a coefficient value such that a unitary pp increase in the measure increases the stock price by about 4.77%. On the other hand, the EONIA Swaps return a p-value that is not statistically significant at any considerable confidence level, while the 3-Month EURIBOR Futures show a p-value of 0.0521 – just short of enough to be significant at the 95% confidence level.

The root of these results is revealed when deconstructing the regression periodically – all the variables show high significance levels during the crisis period. While this fact is transversal to most banks in analysis, Santander's stock shows considerably higher sensitivity to unexpected monetary policy, during this period. During this time, a single pp increase in the daily variation of the 1-Month EONIA Swaps produced a significant increase of 26.85% on the share price, while the same occurrence in the 3-Month EURIBOR Futures generated a rise of over 23.17% on the stock, and in the spread between the 2-Year Bond yields and the 1-Month OIS an increase of approximately 16.47%, with all 3 variables exhibiting approximately null p-values.

After the end of the crisis, each variable's explanatory power decreases once again, to record-low statistically insignificant levels. As such, these findings suggest that a period in which financial markets reacted very strongly to unexpected changes in monetary policy, in relation to Santander's stock, conducted to a new-found period of stability, in which the bank's market valuation shows signs of imperviousness to these surprise changes in policy.

6.1.5. UBS

Swiss bank UBS exhibits a similar patter to the afore-mentioned Santander, as the only measure of unexpected monetary policy which significantly impacts its share price is the spread between the 2-Year Bond yields and the 1-Month OIS. When analysing the full sample period of 2002-2016, the variable returns a p-value of 0.0167, and a coefficient such that a unitary pp increase in the daily variation of the spread causes the stock to appreciate by about 5.32%. Neither one of the remaining variables (1-Month EONIA Swap rate and 3-Month EURIBOR Futures) reveal the existence of a significant relationship between the stock and surprises in monetary policy, with p-values of 0.1596 and 0.1255, respectively.

This pattern persists when running each regression model for specific periods, highlighting effects of the financial crisis. Even during the crisis period of 2008-2012, the stock proved to be more sturdy to surprise changes in monetary policy than in the cases of most other banks, with only the spread in the Bond yields showing significance in this period.

However, the post-crisis analysis reveals that the explanatory power in the spread of the 2-Year yields surges mostly in recent years, with a p-value of 0.0400 and a coefficient value such that a unitary pp increase in the variable actually decreases share price by over

11.67%. The 3-Month EURIBOR Futures also increase in significance in recent years, with a p-value of 0.0310 (now significant at the 95% confidence level), but generating a reverse effect in the stock, incrementing its value by about 28.04%.

6.1.6. UniCredit

Efforts to gauge UniCredit's exposure to surprise changes in monetary policy reveal the existence of a significant relationship between the bank's share price and 2 of the dependent variables, which also increase in significance over time.

When regressing UniCredit's historical share price as a function of the 1-Month EONIA Swap rates' daily change, on days of policy announcements, for the entire period comprised between 2002 and 2016, a p-value of 0.0277 is exhibited, which proves significant at a 95% confidence level and highlights the presence of a significant relationship between the two variables. The regression produces a coefficient value such that a unitary pp increase in the variable causes UniCredit's stock to escalate over 11.32%.

The 3-Month EURIBOR Futures exhibit a similar relationship with UniCredit's stock, returning a p-value of 0.0131, highly significant at the 95% confidence level. Financial markets react to an increase of 1 pp in the interest rate reflected in the futures' price, by increasing UniCredit's share value by about 9.71%, when considering the variable's daily variation in days of monetary policy announcements.

The spread in the 2-Year Government Bond yields and the 1-Month OIS, on the other hand, is the only non-significant variable in explaining the variation of UniCredit's stock price, with a p-value of 0.4259,

Splitting the time series into the pre-crisis, crisis and post-crisis periods provides further insight as to the exhibited results. The first and perhaps most noteworthy find is the increase in significance overtime of the EONIA Swaps, with p-values of 0.6714, 0.1743 and 0.0019, for each respective period (before, during and after crisis). The 3-M EURIBOR Futures, on the other hand, show the inverse occurrence, consistently decreasing in significance, with p-values of 0.3309, 0.4401 and 0.4170. Regarding the spread in the German Government Bonds, the variable increases in significance during and after the crisis period, with respective p-values of 0.0232 and 0.0794. Regarding quantitative impacts on the share price, after the crisis results suggest that a unitary pp increase in the daily variation of the 1-Month EONIA Swaps decreases share price by over 52.29%, while the same increase in the daily variation of the spread in the Bond yields, generates a decrease of about 16.41%.

Additionally, each of the regressions for UniCredit's stock returns reveal the lowest values for the variation coefficient, derived from EGARCH's variance equation, with coefficients of about 0.83 – while the other 5 banks all show coefficients of over 0.98. Without overanalysing, a variance equation coefficient close to 1 suggests that the implied volatility has a "memory", and is influenced by past occurrences.

6.2. Analysis of results

Taking a step back from the individual bank analysis of the results and comparing them allows for several conclusions to be drawn, regarding the initial hypothesis that unexpected monetary policy contractions decrease bank share prices, as well as the overall role that surprise decisions from the ECB produce on financial market's perception of bank equities.

From the exhibited results, perhaps the most blatant conclusion is the fact that the significance/depth of unexpected monetary policy varies greatly by bank – while they are all (or have been), to some degree, affected, judging from the market performance of their stock, some banks show more vulnerability than others. As such, this dissertation successfully establishes a relation between unexpected monetary policy and bank share prices – while some banks' stock proves more resilient to surprise changes in policy and thus the relation is not blatantly observable, testing for shorter sampling periods (before during and after the financial crisis) highlights the presence of a relationship between the two main subjects of discussion, at some point in time.

From the banks subject to analysis, Italian bank UniCredit and English bank HSCB are arguably the ones which display the most exposition to surprise contractionary changes in monetary policy. In the middle of the spectrum are the Spanish bank Santander and Swiss UBS, which are impacted, albeit not heavily, by surprise contractions in monetary policy. Proving more impervious to these unexpected policy changes are the German Deutsche bank and the French BNP Paribas, when subject to a general comparison.

Additionally, the evidence is curious in the sense that it does not allow for the establishment of a direct and obvious linkage between a bank's financial solidity/overall performance and monetary policy. While Deutsche Bank has exhibited massive losses and drops in market value in the last few years (eventually leading to an unavoidable capital increase), BNP Paribas has consolidated its position as one of Europe's largest banks, successfully avoiding considerable losses during the crisis period (unlike other banks including UBS). However, they both exhibit a similar imperviousness to surprise shifts in monetary policy. A similar scenario arises in the comparison of both banks which show a medium correlation with unexpected monetary policy – UBS and Santander. The Swiss bank was among those which suffered highest losses during the financial crisis period, still presently recovering from said losses, with its most recent history being one of attempts to achieve stability and remain competitive in the European market. On the other hand, Santander's history is one of more highs than lows, with its market position increasing drastically in the last few years due to its aggressive acquisitions strategy, consolidating its position worldwide.

6.3. Periodical breakdown and historical evolution

The temporal breakdown analysis for before, during and after the financial crisis produced additional insight as to the historical evolution of the relationship between unexpected monetary policy and bank share prices.

While the results still vary significantly between banks, there are clear patterns and trends from which an analysis can be inferred, from the regressions with samples split into the three time periods considered. As mentioned before, the periodical regression summary conducted for each bank and explanatory variable can be consulted in Appendix 9.9.

6.3.1. Pre-Crisis period (01.01.2001 – 31.10.2008)

Before the financial crisis, there was no clear relation between unexpected monetary policy and bank share prices, with most regressions proving to be non-statistically significant. From the components detailing surprises in policy decisions, changes reflected in the 1-Month EONIA Swaps produce the biggest impact on the bank stocks, successfully explaining its price variation on two of the banks subject to analysis, which increases by about 12 to 14 percent upon a unitary percental point increase in the rate.

This increment in share price derived from surprise policy rate increases seems contradictory with rationale, but could be attributed to the fact that in this period, the role of central bank policy instruments and bank equities was not perfectly clear. Additionally, the term structure of interest rates was entirely different from the one observed in following years. This finding is particularly interesting in that it defies the expectations regarding the relationship between common equities and unexpected monetary policy, suggesting that there are other channels at work when dealing with bank equities, which cause the opposite effect to be the effective one.

The 3-Month EURIBOR Futures is, during this period, the variable with the least explanatory power and overall influence over bank share prices. The spread between the 2-Year German Government Bond yields and the 1-Month OIS shows a similar trend, albeit to a less extent, suggesting financial markets showed some degree of restraint in valuing bank stocks, when confronted with surprise changes in these variables.

6.3.2. Crisis period (01.11.2009 – 31.12.2012)

During the financial crisis of ’09, the depiction changes severely. Half of the banks (with a few notable exceptions) are impacted by surprise changes in monetary policy, with all of them exhibiting a rise in the overall significance of all the dependent variables. In some cases, the explanatory power is so considerable that a unitary percental point increase in the dependent variable increases share price by over 26% (in the most extreme case of Santander and the 1-Month EONIA Swaps).

These results are consistent with the economic instability and overall uncertainty regarding financial markets, during this period. Investors looked to central banks not only to gauge market trends but as a source of information regarding the performance of financial markets worldwide, desperate for official news pointing towards stability, thus reacting very heavily and almost instantly to unexpected changes in monetary policy. Bank share prices, more than other equities and financial products, experienced high volatility during this period of nearly 3 years, being on a vulnerable state, the aftermath of which would require significant efforts to recover from.

6.3.3. Post-Crisis period (01.01.2013 – 31.12.2016)

After the financial crisis’ ‘official’ end, European markets were slowly bouncing back from the hindering effects it had produced, and such was the case of European banks. After experiencing considerable losses and endured a period of high market volatility and instability, European banks began conducting efforts both to repair the damages left in their financial structures as well as to find a new way to conduct their operations and daily business in a solid and more resilient manner.

This trend is similarly present in the analysis of the impact produced by surprise changes in monetary policy. Bank stocks which showed high exposure to unexpected changes in policy during the crisis now return regressions with non-statistically significant outcomes, for most of the dependent variables – as is the case of Santander, which proves to be the one least impacted by surprise changes in policy after the crisis' end.

Comparing the overall pane, and the role that surprise monetary power played in bank share price volatility, before and after the financial crisis, brings to light certain elements that might otherwise remain concealed. While unexpected changes reflected in the 3-Month EURIBOR Futures prove not to have a significant post-crisis impact on the stock price of the banks (with the single exception being UBS), the spread reflected between the 2-Year German Government Bond yields and the 1-Month OIS emerges with a considerably more significant relationship with bank share prices. Such might be an influence of attempts to diversify asset portfolios, as an effort from banks to achieve higher degrees of financial stability and attain term premiums on their investments. This element of speculation is further supported by the fact that for some of the banks in the analysis, one of the variables representative of surprise changes in monetary policy can be very significant in explaining the variation in share price, while to another variable the bank shows near-perfect imperviousness (such is the case of Deutsche Bank's high exposure to changes in the spread reflected in the Bond yields, but near imperviousness to changes in the 3-Month EURIBOR Futures).

Of the banks subject to analysis, HSBC and Santander show a newly-consolidated position and less volatile share price performance, with unexpected changes in ECB monetary policy producing no significant impact on the stocks. Deutsche Bank and UniCredit show the existence of a significant relationship with a single variable representing surprise changes in policy (proving considerable exposure to a single financial instrument subject to policy decisions). Lastly, unexpected changes in policy produce a much higher influence on the share prices of BNP Paribas and UBS than either had experienced before.

The end of the financial crisis also undoubtedly marked a shift in the relation between unexpected monetary policy and bank equities. When faced with an unexpected change in policy, signalled by one of the ECB's instruments and official announcements, investors flock away from bank stocks, effectively placing less value on the equity component and weighing it less in their portfolios. This is arguably the most evident conclusion that can be drawn from a periodical analysis, as after the crisis, values for the coefficient of regression shift to very low negative amounts. This occurs in the case of practically every single bank, especially when the variables measuring surprise policy changes significantly impact the stock price, with the most grievous cases being those of UniCredit, which sees its stock price fall over 52% upon a unitary pp increase in the daily variation of the 1-Month EONIA Swap rate, and BNP Paribas, which observes a decrease of around 23%, when faced with the same event.

This shift in the directionality of the relationship between unexpected monetary policy and bank equities is consistent with the premise that a surprise policy rate increase, through the respective transmission channels, decreases equity prices. As such, although other conduits hint at the opposite event being the one verified when applying this theory to financial institutions, these alternative channels are not strong enough to distinguish bank equities from common stocks, in the sense that both are impacted negatively from unexpected policy rate hikes. This evidence supports the general hypothesis of this dissertation.

6.4. Looking ahead and further research

Future efforts and research could be conducted attempting to provide an explanation as to why surprise shifts in monetary policy generate the impact that they do on bank share prices. An analysis of the asset composition of a bank's portfolio might provide additional insight, as it is logical to speculate that portfolios with official interest rate-related derivatives (like swaps on the EONIA) will have a higher degree of exposition and sensitivity to surprise changes in policy.

A different train of thought worth following is from the individual investor's perspective. While this dissertation has established the existence of a *reaction* from financial markets to unexpected announcements regarding monetary policy, as a whole, survey-based research might reveal how distinct investors make the decision to buy/sell bank shares and most importantly their motivation in doing so.

On the other hand, efforts could be conducted to broaden the spectrum of the general hypothesis of this dissertation, highlighting new insight-providing elements. Variables could be introduced to compare banks by size, geographical scope, or expand to other markets outside Europe, with differently functioning central banks. Additionally, the sample pool of available financial institutions could be broadened such as to consider every European bank (*in extremis*) and extended to insurance companies[5], or consider an industry-focused analysis utilizing diverse types of equities.

[5] Research regarding insurance company valuations and the impact of interest rates has been a focus of equity and actuarial research in modern literature. See Brewer, Carter et al (2007) and Duarte, Silva et al (2015).

7. Conclusions

The basis for this dissertation has been the existence of a meaningful relationship between European monetary policy and bank share prices, aiming to expand on the existing literature regarding the impact of shifts in monetary policy on financial markets, by narrowing the focus on financial institutions.

By resorting to linear regressive models as an attempt to relate historical bank share prices for six large European banks, with variables serving as proxy for unexpected/surprise monetary policy which take into consideration dates of ECB policy announcements, it was possible to achieve empirical evidence supporting the existence of a significant relationship between the two, albeit with its limitations.

The main finding is consistent with the initial premise, under which each of the six European banks subject to analysis has proved to have been significantly impacted by surprise changes in ECB monetary policy, at some point between the years 2002 and 2016.

Interestingly, before the financial crisis the data shows that a surprise policy rate increase actually increased bank equities – which is contrary to what happens with common equities, suggesting there were other transmission channels at work. It was possible to ascertain that during the financial crisis, bank shares were very volatile, with high levels of exposition to shifts in monetary policy. After the end of the crisis, the general trend is for the stocks to signal either a newly-found robustness to surprise changes in policy, or a clearer and more indisputable relationship, judging from regressions run for specific time periods for before, during and after the financial crisis. Not only that, the end of the crisis marked a shift in the relationship between European bank equities and surprise monetary policy, in the sense that unexpected policy rate increases generate a negative impact on the stocks, which is consistent with expectations. This more evident and clear relationship between the two ought to be a direct effect of central banks' more open communication and transparency in the policy-making process, which are methodologically highlighted in this dissertation.

A curious find is that the overall impact of unexpected monetary policy announcements on the share prices seems to vary greatly by bank, with some banks showing a very significant relation while others a virtual imperviousness to surprise changes in policy.

While the most obvious assumption would be that this directly mirrors the financial stability of the banks, with more solid institutions showing little exposition while more debilitated ones showing higher vulnerability, this is not the case, with the opposite being verified in some instances.

Further research on the subject could expand on the reason behind this polarized reaction, broadening the scope to other financial institutions either of different dimensions or outside of the European environment, building upon the foundation that there is, in effect, a relationship between unexpected monetary policy and bank share prices.

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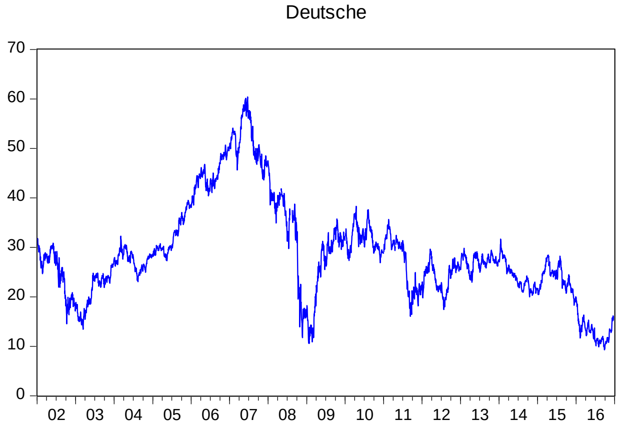
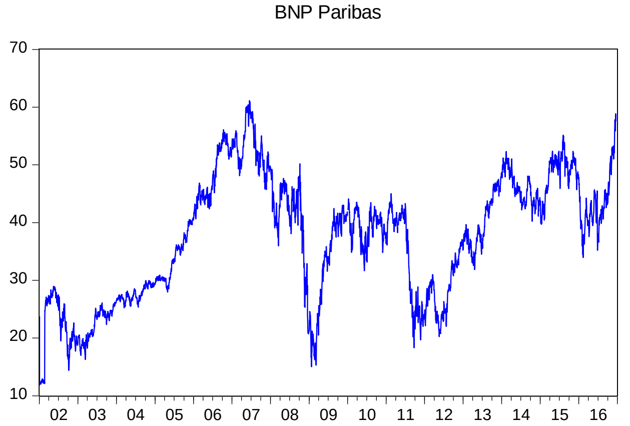
9. Appendix

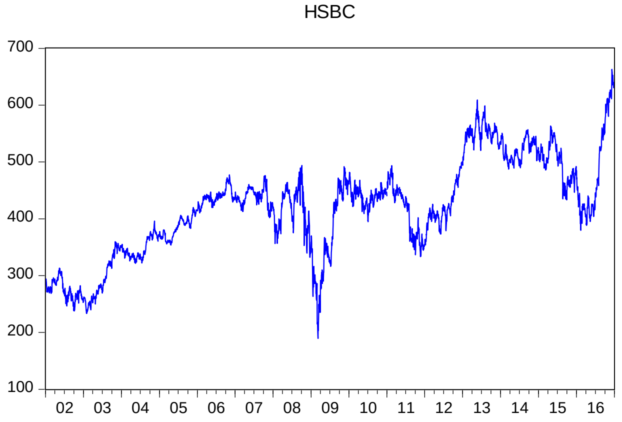
9.1. Graphical representations for the share prices (level, daily). Source: EViews Software.



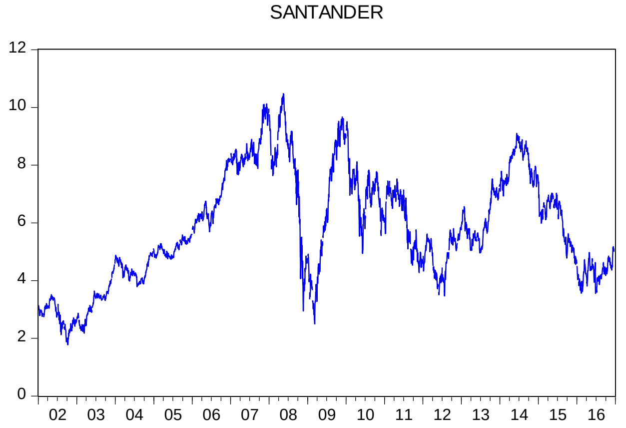
Graphic 1 - Historical daily share price for Deutsche Bank



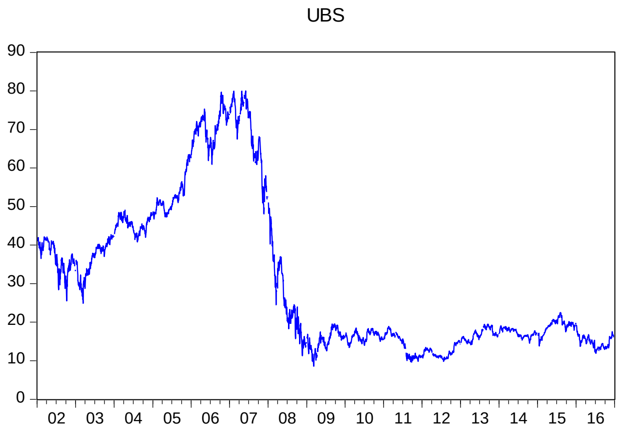
Graphic 2 - Historical daily share price for BNP Paribas



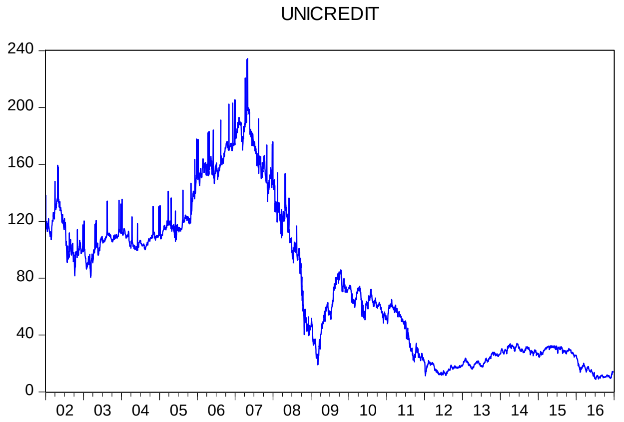
Graphic 3 - Historic daily share price for HSBC



Graphic 4 - Historical daily share price for Santander



Graphic 5 - Historic daily share price for UBS



Graphic 6 - Historic daily share price for UniCredit

9.2. Summary of results from Unit Root tests conducted on the share price variables. Source: adapted from EViews.

Unit Root Tests	Deutsche	BNP Paribas	HSBC	Santander	UBS	UniCredit
Augmented Dickey-Fuller (ADF)						
t-Statistic	-2.05218	-3.00369	-3.34382	-2.15820	-1.44532	-1.90262
p-value	0.5718	0.1312	0.0594	0.5124	0.8476	0.6529
Kwiatkowski-Phillips-Schmidt-Shin (KPSS)						
LM-statistic	0.85409	0.59872	0.26982	0.95444	0.68925	0.72727

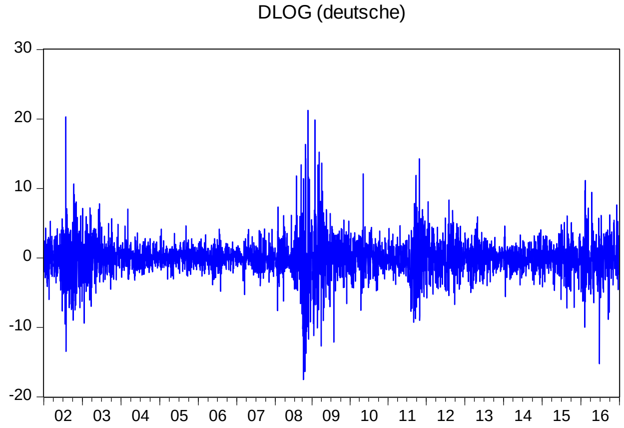
Table 1 - Summary of results for Unit Root tests ADF and KPSS run for the historical share price variables

9.3. Summary of results from Unit Root tests conducted on the DLOG variables. Source: adapted from EViews.

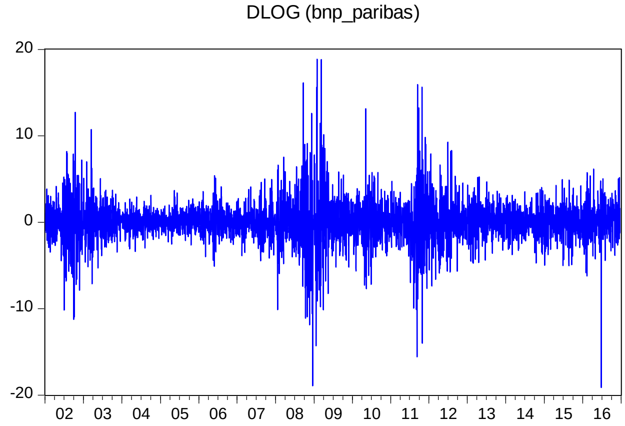
Unit Root Tests	Deutsche	BNP Paribas	HSBC	Santander	UBS	UniCredit
Augmented Dickey-Fuller (ADF)						
t-Statistic	-60.51933	-38.73403	-64.08108	-65.43738	-38.51121	-42.83947
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Kwiatkowski-Phillips-Schmidt-Shin (KPSS)						
LM-statistic	0.03518	0.04420	0.03265	0.03127	0.11331	0.05160

Table 2 – Summary of results for Unit Root tests ADF and KPSS run for the natural logarithm of the returns (DLOG) variables

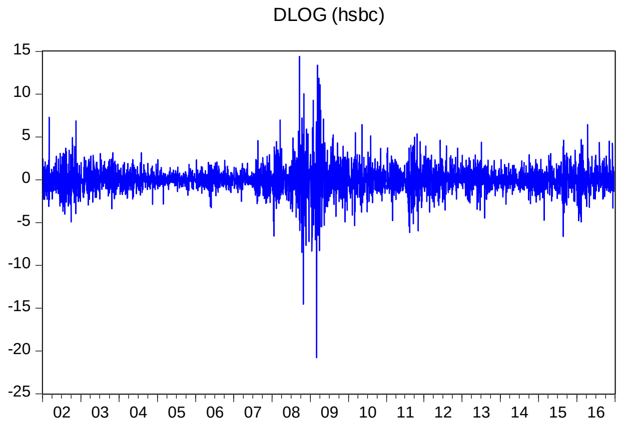
9.4. Graphical representation for the DLOG variables (natural logarithm of the returns). Source: EViews Software.



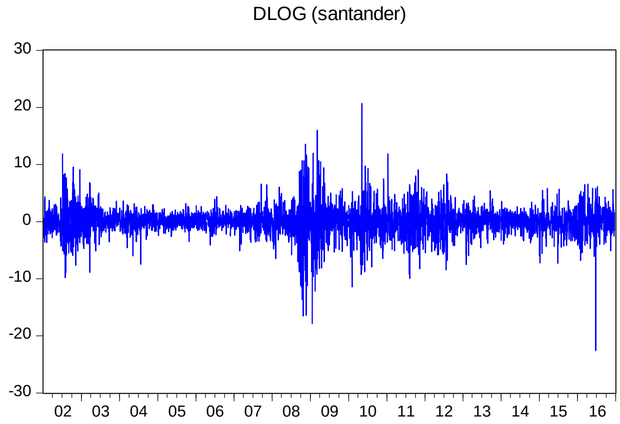
Graphic 7 - Historic log returns for Deutsche Bank



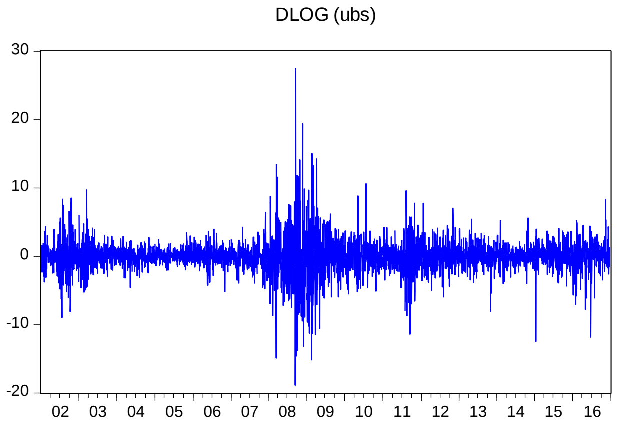
Graphic 8 - Historic log returns for BNP Paribas



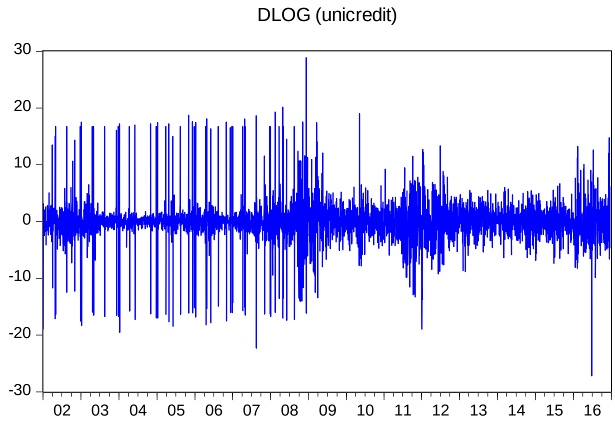
Graphic 9 - Historic log returns for HSBC



Graphic 10 - Historic log returns for Santander



Graphic 11 - Historical log returns for UBS



Graphic 12 - Historical log returns for UniCredit

9.5. Summary of results from the Engle ARCH-LM test for GARCH effect conducted on the DLOG variables. Source: adapted from EViews.

Engle ARCH-LM test	Deutsche	BNP Paribas	HSBC	Santander	UBS	UniCredit
F-statistic	264.3343	89.6372	141.4963	160.9948	169.9662	365.6509
Prob. F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Prob. Chi-Square	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 3 – Summary of results for the Engle ARCH-LM test for the natural logarithm of the returns (DLOG) variables

9.6. Main statistical elements and choice of econometric models for the time series (DLOG variables with the 100 multiplier). Source: adapted from EViews.

Descriptive Statistics	Deutsche	BNP Paribas	HSBC	Santander	UBS	UniCredit
Mean	-0.0180	0.0225	0.0210	0.0129	-0.0251	-0.0593
Median	0	0	0	0.0941	0	0
Maximum	21.2452	18.8745	14.4231	20.6940	27.5064	28.8709
Minimum	-17.5357	-19.1164	-20.7989	-22.5751	-18.8910	-27.1658
Std. Dev.	2.6236	2.4806	1.6224	2.5336	2.4338	3.9121
Skewness	0.2552	0.0746	-0.2175	-0.3143	0.1572	0.0628
Kurtosis	11.1703	11.3684	18.7349	10.7725	15.0747	12.5459
Jarque-Bera	10850.83	11406.75	40304.71	9566.98	22905.97	14829.29
Probability	0	0	0	0	0	0
Sum	-70.0454	87.8675	81.9308	48.7994	-94.6549	-231.3761
Sum Sq. Dev.	26741.9700	24042.0300	10273.2400	24231.4400	22312.6900	59749.7800
Observations	3886	3908	3904	3776	3768	3905
ARMA	**(0,1)**	**(0,0)**	**(1,1)**	**(0,1)**	**(0,1)**	**(1,1)**
GARCH	**EGARCH(1,1)**	**EGARCH(1,1)**	**EGARCH(1,1)**	**EGARCH(1,1)**	**EGARCH(1,1)**	**EGARCH(1,1)**

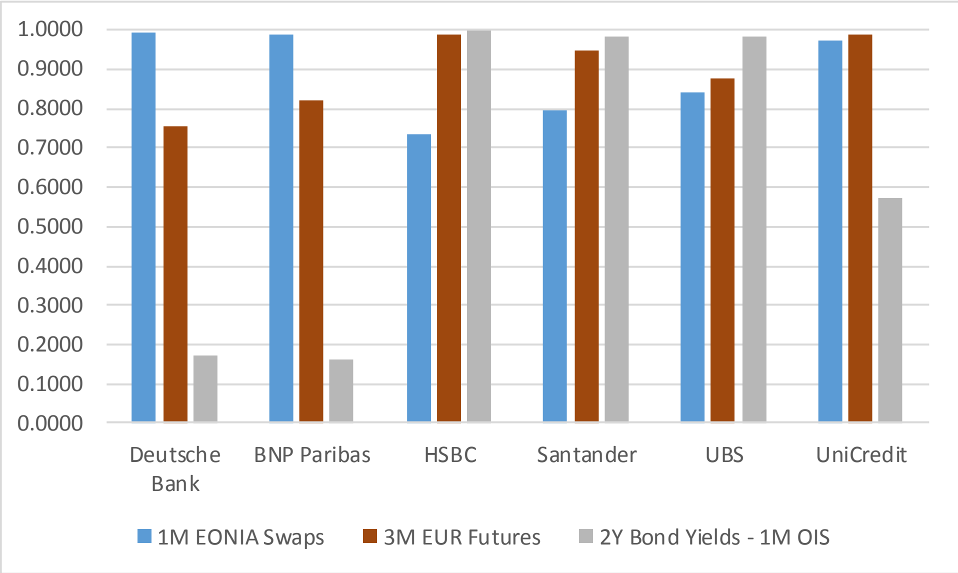
Table 4 - Statistical summary of econometric values for the time series

9.7. Simple Linear Regression outputs, for the entire sample (01.01.2002 to 31.12.2016). Source: Adapted from EViews Software.

	Deutsche Bank	BNP Paribas	HSBC	Santander	UBS	UniCredit
1M EONIA Swaps						
Coefficient	12.3828	9.8474	3.6454	6.5551	7.0170	11.3225
p-value	0.0061	0.0123	0.2636	0.2051	0.1596	0.0277
Akaike IC	4.2371	4.1466	3.2690	4.2074	3.9767	4.7599
Adjusted R-squared	0.0047	0.0025	0.0033	0.0034	0.0098	0.0128
Std. Error of Regression	2.6174	2.4776	1.6199	2.5292	2.4218	3.8758
Variance Eq. Coefficient	0.9922	0.9900	0.9882	0.9907	0.9892	0.8368
3M EUR Futures						
Coefficient	4.2654	4.8922	5.9068	8.1502	-4.8302	9.7062
p-value	0.2474	0.1787	0.0099	0.0521	0.1255	0.0131
Akaike IC	4.2378	4.1469	3.2680	4.2067	3.9768	4.7596
Adjusted R-squared	0.0014	0.0005	0.0036	0.0052	0.0087	0.0107
Std. Error of Regression	2.6218	2.4801	1.6197	2.5270	2.4231	3.8799
Variance Eq. Coefficient	0.9921	0.9901	0.9882	0.9906	0.9892	0.8361
2Y Bond Yields - 1M OIS						
Coefficient	0.4935	-0.4119	3.6834	4.7717	5.3212	1.7301
p-value	0.8260	0.8407	0.0034	0.0192	0.0167	0.4259
Akaike IC	4.2381	4.1473	3.2679	4.2068	3.9758	4.7603
Adjusted R-squared	0.0004	-0.0004	0.0028	0.0065	0.0089	0.0109
Std. Error of Regression	2.6231	2.4811	1.6203	2.5253	2.4229	3.8796
Variance Eq. Coefficient	0.9921	0.9901	0.9882	0.9907	0.9891	0.8355

Table 5 - Output of main regression estimates for each of the variables and measures of surprise monetary policy

9.8. Graphical representation of the p-value for the T-test observed in the regressions, per bank. The p-value was subtracted from 1 to reflect the level of significance – for example, a p-value of 0.000, which represents a high significance, becomes the value of 1.



Graphic 13 - Graphical representation of the p-value of the t-test, for the coefficients of the regression

9.9. Table-Summary of regressions for before, during and after Financial Crisis. Source: adapted from EViews.

9.9.1. Deutsche Bank

	Deutsche Bank		
	Pre-crisis	Crisis	Post-crisis
1M EONIA Swaps			
Coefficient	14.2236	15.0503	-2.8622
p-value	0.0489	0.1099	0.7859
Akaike IC	3.9393	4.7892	4.1785
Adjusted R-squared	0.0060	0.0044	0.0016
Std. Error of Regression	2.4072	3.2553	2.1903
Variance Eq. Coefficient	0.9877	0.9940	0.9896
3M EUR Futures			
Coefficient	0.9949	9.1181	2.6258
p-value	0.8479	0.2250	0.7979
Akaike IC	3.9404	4.7904	4.1786
Adjusted R-squared	-0.0012	0.0023	0.0017
Std. Error of Regression	2.4159	3.2589	2.1902
Variance Eq. Coefficient	0.9875	0.9939	0.9896
2Y Bond Yields - 1M OIS			
Coefficient	-0.6399	5.6820	-18.7033
p-value	0.8213	0.1447	0.0232
Akaike IC	3.9404	4.7900	4.1732
Adjusted R-squared	-0.0015	0.0026	0.0058
Std. Error of Regression	2.4162	3.2583	2.1857
Variance Eq. Coefficient	0.9875	0.9938	0.9882

Table 66 - Periodical regression outputs for Deutsche Bank

9.9.2. BNP Paribas

	BNP Paribas		
	Pre-crisis	Crisis	Post-crisis
1M EONIA Swaps			
Coefficient	11.5912	18.5394	-23.0640
p-value	0.0448	0.0689	0.0267
Akaike IC	3.8435	4.8346	3.9432
Adjusted R-squared	0.0041	0.0033	0.0001
Std. Error of Regression	2.1081	3.3821	1.8797
Variance Eq. Coefficient	0.9903	0.9933	0.9535
3M EUR Futures			
Coefficient	1.9783	8.7539	7.3412
p-value	0.6910	0.3038	0.3762
Akaike IC	3.8447	4.8372	3.9453
Adjusted R-squared	-0.0001	0.0003	-0.0013
Std. Error of Regression	2.1127	3.3872	1.8811
Variance Eq. Coefficient	0.9904	0.9934	0.9518
2Y Bond Yields - 1M OIS			
Coefficient	-0.6442	6.2278	-15.8751
p-value	0.7983	0.1795	0.0252
Akaike IC	3.8447	4.8365	3.9410
Adjusted R-squared	-0.0007	0.0020	0.0024
Std. Error of Regression	2.1132	3.3843	1.8775
Variance Eq. Coefficient	0.9904	0.9934	0.9522

Table 7 - Periodical regression outputs for BNP Paribas

9.9.3. HSBC

	HSBC		
	Pre-crisis	Crisis	Post-crisis
1M EONIA Swaps			
Coefficient	2.7805	8.8469	-3.0164
p-value	0.5601	0.0747	0.8148
Akaike IC	2.9480	3.8878	3.1912
Adjusted R-squared	0.0078	0.0075	-0.0033
Std. Error of Regression	1.3987	2.1583	1.2829
Variance Eq. Coefficient	0.9886	0.9927	0.9535
3M EUR Futures			
Coefficient	4.2515	7.1110	13.3255
p-value	0.1749	0.1753	0.0583
Akaike IC	2.9469	3.8851	3.1846
Adjusted R-squared	0.0086	0.0029	-0.0019
Std. Error of Regression	1.3982	2.1633	1.2820
Variance Eq. Coefficient	0.9886	0.9929	0.9531
2Y Bond Yields - 1M OIS			
Coefficient	3.4084	4.2407	-0.5027
p-value	0.0152	0.2403	0.9096
Akaike IC	2.9461	3.8881	3.1868
Adjusted R-squared	0.0088	0.0022	-0.0016
Std. Error of Regression	1.3980	2.1641	1.2818
Variance Eq. Coefficient	0.9886	0.9923	0.9534

Table 8 - Periodical regression outputs for HSBC

9.9.4. Santander

	Santander		
	Pre-crisis	Crisis	Post-crisis
1M EONIA Swaps			
Coefficient	-4.5928	26.8515	-0.0079
p-value	0.5999	0.0032	0.9994
Akaike IC	3.8198	4.9661	4.0821
Adjusted R-squared	0.0091	0.0045	-0.0023
Std. Error of Regression	2.1414	3.3826	2.0562
Variance Eq. Coefficient	0.9908	0.9814	0.9788
3M EUR Futures			
Coefficient	3.7224	23.1771	16.8231
p-value	0.5374	0.0011	0.1943
Akaike IC	3.8198	4.9666	4.0811
Adjusted R-squared	0.0102	0.0038	-0.0007
Std. Error of Regression	2.1402	3.3837	2.0546
Variance Eq. Coefficient	0.9908	0.9805	0.9782
2Y Bond Yields - 1M OIS			
Coefficient	1.5210	16.4662	4.3966
p-value	0.5391	0.0007	0.4696
Akaike IC	3.8199	4.9642	4.0819
Adjusted R-squared	0.0104	0.0107	-0.0019
Std. Error of Regression	2.1400	3.3721	2.0558
Variance Eq. Coefficient	0.9908	0.9816	0.9784

Table 97 - Periodical regression outputs for Santander

9.9.5. UBS

	UBS		
	Pre-crisis	Crisis	Post-crisis
1M EONIA Swaps			
Coefficient	10.3012	15.0767	-12.9991
p-value	0.2114	0.1167	0.3430
Akaike IC	3.7272	4.5769	3.7399
Adjusted R-squared	0.0134	0.0063	0.0112
Std. Error of Regression	2.3988	2.9516	1.7538
Variance Eq. Coefficient	0.9807	0.9950	0.9175
3M EUR Futures			
Coefficient	-5.5163	-12.9510	28.0428
p-value	0.1596	0.1190	0.0310
Akaike IC	3.7277	4.5772	3.7338
Adjusted R-squared	0.0104	0.0080	0.0145
Std. Error of Regression	2.4025	2.9492	1.7508
Variance Eq. Coefficient	0.9809	0.9948	0.9115
2Y Bond Yields - 1M OIS			
Coefficient	4.0721	10.5538	-11.6704
p-value	0.1313	0.0207	0.0400
Akaike IC	3.7273	4.5731	3.7380
Adjusted R-squared	0.0092	0.0109	0.0136
Std. Error of Regression	2.4039	2.9449	1.7516
Variance Eq. Coefficient	0.9809	0.9943	0.9117

Table 10 - Periodical regression outputs for UBS

9.9.6. UniCredit

	UniCredit		
	Pre-crisis	Crisis	Post-crisis
1M EONIA Swaps			
Coefficient	2.2862	18.0801	-52.2910
p-value	0.6714	0.1743	0.0019
Akaike IC	4.3524	5.1860	4.6791
Adjusted R-squared	0.0173	0.0026	0.0007
Std. Error of Regression	4.3704	3.8737	2.8663
Variance Eq. Coefficient	0.5150	0.9892	0.9602
3M EUR Futures			
Coefficient	3.9436	7.1564	11.4639
p-value	0.3309	0.4401	0.4170
Akaike IC	4.3521	5.1877	4.6837
Adjusted R-squared	0.0168	-0.0002	-0.0004
Std. Error of Regression	4.3714	3.8791	2.8678
Variance Eq. Coefficient	0.5150	0.9891	0.9672
2Y Bond Yields - 1M OIS			
Coefficient	0.4948	11.0087	-16.4094
p-value	0.8173	0.0232	0.0794
Akaike IC	4.3524	5.1850	4.6814
Adjusted R-squared	0.0166	0.0035	0.0020
Std. Error of Regression	4.3719	3.8720	2.8645
Variance Eq. Coefficient	0.5145	0.9889	0.9665

Table 11 - Periodical regression outputs for UniCredit