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Monetary Policy and Equity Prices

- An Event Study from Denmark

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Executive Summary

Monetary policy and its effect on capital markets has been a subject of great interest in recent years, especially since the Great Recession unfolded in 2008, with central banks across the globe subsequently embarking on unprecedented measures to enhance stability. The conventional wisdom within economics and a substantial part of the recent research regarding unconventional monetary policy, both suggest, all else equal, that there is a negative relationship between a looser monetary policy, i.e. a lower monetary policy interest rate, and asset prices. When applying this to Danish monetary policy and Danish equity prices during the period 2008-2015, we initially, and to our surprise, find that there exists a positive relationship. After a further investigation of the matter, we demonstrate that this can be attributed to the European Debt Crisis and the uncertainty that surrounded it. As such, we find that the conventional and expected relationship holds, albeit in a more indirect manner. We further find that the unconventional monetary policies conducted by Danmarks Nationalbank provide support for the conventional relationship between monetary policy and equity prices, a majority of the recent research regarding unconventional monetary policy's effect on equity prices, and the development of Danish equity valuations in the period 2014-2015.

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PART I – Introduction

1. Introduction

A lot has changed within the monetary sphere since the Swedish King established the first central bank in 1656. Like now, the ruler appointed the banks' management and made stability a key objective. However, monetary policy did not concern the public to the same extent as it has in recent years. Ever since the "Great Recession" manifested itself with the bankruptcy of Lehman Brothers in September 2008, central bankers and their monetary policies have been at the epicenter of financial news throughout the globe. In response to the magnitude of the crisis and its effects on global financial markets, central banks across the world initiated some unprecedented programs in order to avoid a breakdown of the financial system and, later on, to stimulate economic growth. Due to their very nature, these programs are referred to as unconventional monetary policies, as the conventional way of conducting monetary policy proved to be inefficient. The consequences, both the direct and indirect, of monetary policies conducted by central banks have been discussed and studied extensively. Yet, it doesn't seem to have emerged a definite consensus among economists as what and how much ought to be done, if anything, by using monetary policy, what to be achieved, and exactly what has been achieved by it thus far. Nevertheless, there seems to be an agreement regarding the conventional relationship between the interest rates controlled by central banks, and asset prices: it is negative. That is, a looser monetary policy is, all else equal, expected to increase asset prices. Moreover, a majority of the recent research considering the effect of unconventional monetary policies and asset prices has reached the same conclusion.

To our knowledge, there has not been conducted any thorough analysis of monetary policy and its effect on capital markets applied to Denmark, given the recent global developments. As such, we would like to answer the following question:

How has monetary policy events affected Danish equity prices in recent years, given the DKK/EUR peg, the European Debt Crisis and the introduction of unconventional monetary policies?

To address this question, our problem statement, the impact of the actions and announcements of the central bank of Denmark will be closely examined. Furthermore, since maintaining the euro-peg is the main objective of Danish monetary policy, a similar

investigation will be conducted of the European Central Bank. We will further explore equities with different characteristics, and examine different time periods.

In order to answer this problem statement, the assignment is structured as follows:

- Part I: *Introduction*
  - Introduction, Problem Statement, Methodology and Delimitation
- Part II: *Monetary Policy Overview*
  - Currency Regimes, Money and Central Banks, Conventional/Unconventional Monetary Policy
- Part III: *Monetary Policy in Denmark*
  - History, Current Arrangement, Unconventional Monetary Policy in Denmark
- Part IV: *Monetary Policy and Equity Prices*
  - The case for increased/decreased equity prices, Danish equity valuations
- Part V: *Prior Research*
  - *Unconventional monetary policy on bond yields/equity prices*
- Part VI: *Analysis*
- Part VII: *Results*
- Part VIII: *Discussion and Conclusion*

2. Methodology

In this section we will briefly account for the methods used and how the parts, as mentioned in the problem formulation, work together.

This assignment is closest related to an event-study. We use historical data and modify it to account for potential statistical pitfalls, and to fit within the framework of regression analysis. Using this financial market data, mainly obtained by Bloomberg Terminal, we set out to measure the impact of monetary policy events on Danish equity prices. The conclusion reached by Bernanke & Kuttner (2005) and Wright (2012), that there is a negative relationship between a looser monetary policy, conventional and unconventional, and equity prices, will guide our guideline throughout our assignment. Following the framework of Wright (2012), we use a Principal Component analysis in order to measure this impact. As

such, we follow a deductive method, as we try to derive new conclusions from conventional wisdom and similar studies applied to other countries. The efficient market hypothesis lies at the foundation of our assignment, since we assume that the effects of the events will be reflected immediately in the equity prices. With this in mind, we fully acknowledge that, due to the size and openness of Danish capital markets, using intraday data would be highly desirable, which unfortunately we were not able to obtain. Nevertheless, by using the closing price of stock indices and Treasuries, we believe our results are able to capture much of the effect. Furthermore, the results are all found using null hypotheses and all results are accompanied by t-statistics or p-values. The specific models used are explained in detail in their respective sections along with their results. We have throughout the assignment commented and verified, to the best of our ability, causality between dependent and independent variables, as well as the use of prior research regarding monetary policy coupled with founded economic theory.

The descriptive section of the assignment, Part II-V, is meant to give the reader a sufficient insight regarding currency regimes, monetary policy in general, unconventional monetary policy, and monetary policy in Denmark. Moreover, economic theory and prior research that tries to explain or establish the link between monetary policy and asset prices are introduced to the reader. This insight, in turn, will be used to construct and explain both our models and their results.

The model and result sections in Part VI and VII, the analytical section, are set up to represent the progression of our research. Our initial results seemed to contradict the conventional relationship between monetary policy and equity prices. As such, further analysis was conducted on a continuous basis, which resulted in a conclusion that seems to support this conventional relationship, albeit in a more indirect way. The different models and their inputs will be explained in their respective sections.

Part VIII sums up our results and provide a thorough analysis thereof, using well-established economic theory and prior research regarding monetary policy and equity prices.

We have, to our best ability, sought reliable sources of data, and abstained from using third party websites. Data availability does, however, vary from source to source. Still, all of our data should be retrievable, provided that the reader has access to Bloomberg Terminal and

the Internet. Most of the prior research papers utilized in this assignment consist of peer-reviewed articles found in highly recognized economic journals, made available to us through CBS, or papers released by reputable international institutions, such as IMF, NBER, Fed, ECB etc.

3. Delimitations

Fiscal policy will have a significant influence on macroeconomic factors and, as such, also on the effectiveness of monetary policy. However, writing about fiscal policy in Denmark and throughout the Eurozone, its implications and influence on monetary policy, would require an additional thesis. Accordingly, we acknowledge the importance and influence of fiscal policy, but we will focus on the initial consequences of monetary policy on capital markets.

For the very same reason, we will not analyze or discuss the "bank packages" launched by the Danish government during the financial crisis, despite their relevance to the Danish financial system.

The development and earlier framework of Danmarks Nationalbank will briefly be mentioned, but it is the current framework of Danmarks Nationalbank and ECB that will be of interest in this assignment. Moreover, in our models, we will use data from the period 2006 to end of first quarter 2015. In other parts of the assignment, other time periods may be used to illustrate a relevant theory, relationship or trend. However, no data from later than the 3rd of April 2015 has been included in this paper.

Further, we will not elaborate on whether different monetary policies are "good" or "bad". We simply want to try to capture the effect it has on capital markets and the reallocation process. Hence, the question of whether monetary policy has historically contributed to distorting prices, signals and incentives, and whether current unconventional monetary may have created asset bubbles, will not be addressed in much detail, if any.

Details regarding the delimitations and potential shortcomings of our models will be given in the respective model-sections.

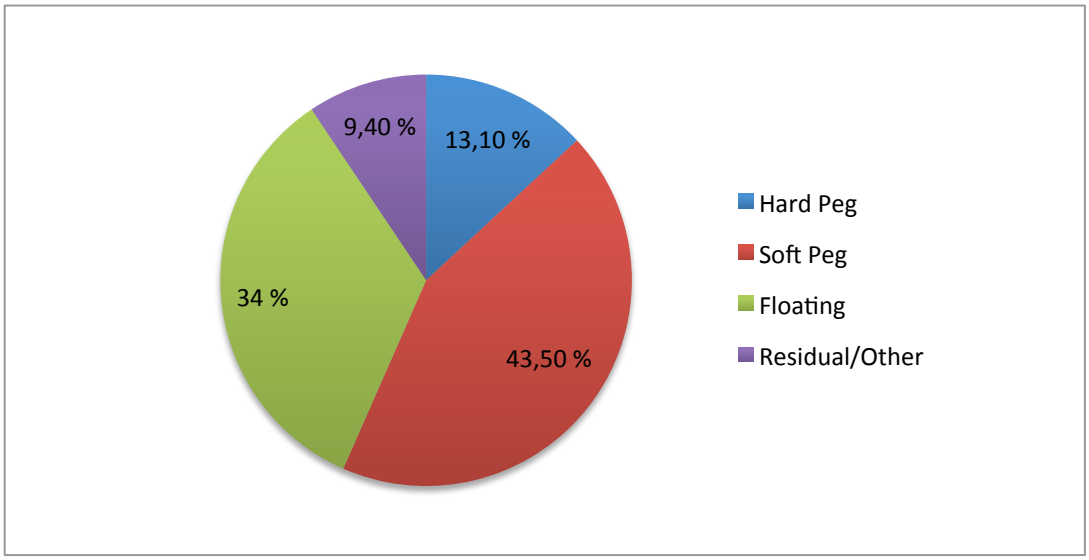
PART II - Monetary Policy Overview

4. Currency Regimes

For most of monetary history, civilized countries have essentially operated with a fixed exchange-rate system in between them. That is because precious metals, more often than not, have been the money of choice in societies, either the physical metal itself or a certificate giving the owner a claim on a specified amount of the metal. These certificates eventually evolved into national currencies. For instance, the British Pound Sterling was originally defined as one pound of silver (Rothbard 1963). As such, the currencies were simply definitions of units of weight and, hence, fixed against each other, even though suspended convertibility and devaluations occurred now and then. It was not until the breakdown of the Bretton Woods system in 1971, when President Nixon detached the US Dollar from gold, that the concept of floating exchange rates and flat currencies became an integrated part of the global economic system. Under a freely floating exchange rate regime, supply and demand dictates what the exchange rate will be. Typically, exchange rate regimes are divided into three broad categories: "hard" exchange rate pegs, floating exchange rate, and all that is in between, often called "soft" exchange rate pegs. The figure below illustrates the global distribution of currency regimes.

Figure 1. Representation of the relative distribution of exchange rate regimes.

The picture in figure 1 is a representation of data gathered from the IMF. It is created on basis of information gathered from the IMF. [1]



[1]www.imf.com
[2]www.google.com/finance
[3]www.bloomberg.com
[4] www.nationalbanken.dk
[5] www.dst.dk

4.1. The "Mundell-Fleming Trilemma"

The Mundell-Fleming model is an economic model that has been used to argue that a central bank cannot simultaneously maintain a fixed exchange rate, free capital movement and an independent monetary policy (Obstfeld et al. 2004). A central bank has to forgo one of the aforementioned objectives. Consequently, it has to choose between three policy combination options:

1. Stable exchange rate and free capital flow, but no independent monetary policy (Hong Kong)
2. Independent monetary policy and free capital flow, but no stable exchange rate (Canada)
3. Stable exchange rate and independent monetary policy but no free capital flow (China)

The underlying theory of this "Trilemma" is the uncovered Interest Rate Parity condition, which states that in absence of a risk premium, arbitrage will ensure that the increase/decrease of a country's currency vis-à-vis another will equal the nominal interest rate differential between them (Bodie et al. 2011) Simply put, the domestic interest income should equal foreign interest income expressed in the domestic currency. If, then, a central bank in a country with a stable exchange rate and free capital flow decides to change the interest rate, global financial players will immediately put pressure on the currency in question, either to the downside or the upside. Initially, the central bank can defend the fixed exchange rate by selling/buying foreign currencies, but eventually it either has to give up the stable exchange rate, impose capital controls or change the interest rate to a level that justifies the stable exchange rate.

It is argued that even absent a stable exchange rate there could still be limited monetary autonomy (Rose 2011). Nonetheless, by using data covering 130 years, the National Bureau of Economic Research found that the constraints implied by the Trilemma are to a large degree borne out by history (Obstfeld et al. 2004).

4.2. Denmark's Currency Regime

Denmark's currency regime, according to IMF, follows a soft peg, or a conventional peg to be exact (IMF 2014).

Currently, Denmark operates with a currency peg vis-à-vis the euro. As it doesn't operate with strict capital controls, Denmark has chosen the number 1 policy combination listed above. The official DKK/EUR central rate is 7,46038 DKK per EUR and the official deviation band is set to ±2,25%. Why this is an objective and how it is maintained, will be further elaborated on later in the assignment. Nevertheless, and as the figure below illustrates, the Danish central bank has displayed an admirable dedication to this objective, with a resulting robust stability in the exchange rate over time.

Figure 2. EUR/DKK historical data.

The graph below in figure 2 represents the historical nominal exchange rate between the euro and the Danish krone. It is taken from Google finance.[2] It spans from 2000 to early 2015.

In order to achieve this, however, and in line with the Trilemma, Danmarks Nationalbank has, at times, been forced to sell and buy foreign currencies at significant amounts, and even deviates from ECB's monetary policy by unilaterally increase/decrease monetary policy interest rates in order to maintain the fixed exchange arrangement.

[2]www.google.com/finance

5. Monetary Policy

A lot has definitely changed within the monetary sphere since the first central bank was established in Sweden in 1656. Much like now, the ruler of the land appointed the bank's management.

However, monetary policy didn't interest the public to the same extent as today, where central bankers and the monetary policies they initiate, even their specific choice of words during public speeches, are at the epicenter of the global financial media. Since the outbreak of the recent financial crisis, central banks across the globe have introduced unprecedented measures, often referred to as unconventional monetary policies, to stabilize the economic environment and to pave the way for economic growth to be materialized. Its consequences, both the directly and indirectly, have been discussed and studied extensively. That it indeed has an impact on the economy is a broad agreement found in academia. Yet, there has not emerged a consensus as to the size and duration of the impact, the precise channel through which it works, or whether it is for better or worse for the coming years (Joyce et al. 2012).

5.1. Money and Central Banks

Few inventions, if any, have had such an influence on human society than that of money. Prior to the introduction of money to the market place, people had to participate in direct exchanges, or barter, to obtain goods and services. This was obviously better than self-sufficiency, but still quite troublesome. It was only when money came about that people could achieve broader vocational specialization. Money became the medium through which one specialist can exchange his product for the goods of other specialists, a system of indirect exchange that simplified trade tremendously. Besides being the medium of exchange, money must also function as a store of value and as a unit of account (Grell & Rygner 2008). Furthermore, to be widely accepted as money, it should also be easily divisible and portable, scarce, and durable. Precious metals have for the most part been the most successful contender in fulfilling these requirements throughout history, but other commodities such as salt and shell have also been used. What is crucial when it comes to money, of any sort during any time, is that it possesses the confidence of the people. The people must be certain that their particular type of money will be accepted in exchange for goods and services today, tomorrow and further into the future. What this confidence really boils down to, then, can be summarized in one word: *stability*. That is, what you are able to obtain for your given amount

of money, the purchasing power of money, remains stable over time. Hence, stability is at the foundation of a successful monetary unit, at the very least in the short- and medium term. Its absence has caused many currencies to lose the confidence it had among the people and eventually collapse. The desired stability within the monetary system, which included the banking sector, was the reason behind most central bank establishments, including the Danish central bank. The people demanded stability and the central banks were the institutions to supply it. Thus the stability is helping the market mechanism to work more effectively, and it is a good approximation to say that the goal of monetary policy should be price stability (Woodford 2003). To be able to achieve this stability, most central banks were granted the control over the money supply, with the monopoly to issue the country's currency. Also, to stop bank runs, bank failures and the associated losses, many central banks were constructed as a Lender of Last Resort in times of severe distress, to stabilize the monetary system as a whole, not just prices. Due to its monopoly and status as the lender of last resort, a central bank is perceived as the bankers' bank (Rothbard 1963). Finally, the central banks were also to attend to the financing needs of the government in times of crises, for the most part during war. Compared to money, central banks are relatively young. The Federal Reserve, for instance, celebrated its 100th anniversary in December 2013, and nearly 70% of the world's central banks were founded after 1950 (BIS 2009). This may be one contributing factor to the prevailing unachieved consensus among economists regarding monetary policy. How these central banks create and maintain stability in the modern monetary system is the topic of the next two sections.

5.2. Conventional Monetary Policy

Probably the most obvious power of any modern central bank is its ability to influence market interest rates. Even though the mechanism differs among countries, most use a similar approach based on the central banks' capability to create fiat money, and thus increase the money supply, at will. Central banks intervene in the market by buying or selling securities to effectively increase or decrees the money supply, respectively. This intervention is called an open market operation. When a central bank buys securities from banks, for instance government treasuries, the money stock at the bank increases. This, in turn, will make money more plentiful and hence reduce the borrowing cost. Also, the central bank is reducing the supply of the particular security through its purchase and increasing the price. Since price and

interest rate are uncorrelated in the case of bonds, the interest will fall, all else equal. In addition, since bonds with similar maturities can be seen as non-perfect substitutes, arbitrager will see to it that there is, at least to some extent, a reduction in interest rates across different maturities (Greenwood & Vayanos 2010). The Federal Reserve, for instance, conducts open market operations to achieve its stated benchmark interest rate, the federal funds rate, which is an interbank overnight lending rate. Central banks also have other interest rate they can set directly, such as its lending rate and deposit rate, to incentivize banks in expansionary and concretionary ways. According to the classical IS-LM model constructed by Hicks, which was the leading framework of macroeconomic analysis between the 1940s and mid 1970s, an increase in money supply, roughly speaking, will decrease the interest rate, which again will increase investment and aggregate demand, and finally materialize in an increased GDP (Bentolila 2005). All else equal, a lower borrowing cost will incentivize investments, and at the same time favor consumption over saving. In addition, it lessens the debt burden of households, companies and governments. That is not to say, however, that conducting expansionary monetary policy over time is without any potential downside. Even though it is outside the scope of this assignment, it is worth noting that expansionary monetary policy can contribute to significant distortions in the economy, for instance asset bubbles or hyperinflation. In times of economic and financial distress, central banks are expected to act as a Lender of Last Resort, in order to temporary stabilize the banking system. The British journalist and businessman Walter Bagehot laid out the basic foundation for this role in the latter part of the nineteenth century with the following three main proposals, which later became known as Bagehot's Dictum (Goodheart 1999):

1. Lend freely
2. … at a high rate of interest
3. … against good banking securities

In other words, provide funds to solid banks that can handle a high interest rate and provides high-quality securities as collateral. The insolvent banks, however, should be allowed to go bankrupt. According to Bagehot, these proposals would assist in the task of getting rid of instability and moral hazard in the financial sector. Finally, some central banks set the reserve ratio banks are required to satisfy, where a reduction in this ratio represents an expansionary policy.

5.2.1 Inflation Targeting

As implicitly pointed out above, liquidity management is the essential task of any central bank, where the desired outcome is, more often than not, price stability. Nowadays, many argue that monetary policy does not have any positive impact on the real economy in the long-term, only inflation. The traditional Phillips curve theory, which argued that there is a trade-off between inflation and unemployment, was severely disproven during the "stagflation" of the 1970's. Therefore, the central banks, only affecting inflation in the long-term, should, it is argued, aim for price stability. In this context, price stability does for the most part not mean a stable price level per se, but rather a stable and low *increase* in the price level. In recent years, a growing number of central banks have adopted explicit inflation targets as the defining principle that should guide the conduct of monetary policy (Woodford 2003). Prior to this approach, which was developed by the central banks of New Zealand, Canada, England and Sweden on a trial-and-error basis, it was widely believed that the most suitable approach was to delegate the task to the best possible professionals and grant them full discretion. Because central banking is a complex task, the argument goes, any explicit target would severely restrain the full exercise of the judgment of central bankers on behalf of society when unanticipated circumstances arise, as they invariably do. However, since market participants are forward-looking, central banks affect the economy as much through their influence on expectations as through any direct, mechanical effect, as expectations regarding future policy matter for what can be achieved by the private sector at any point in time (Woodford 2003). The adoption of inflation target is found to actually improve the forecasting accuracy of the private sector (Crowe & Meade 2008). As such, it reduces investor uncertainty, and through the central bank's commitment to its stated target, given that it is communicated in an effective manner, increases its transparency and accountability. In fact, according to Woodford (2003), it is more important that there is an explicit *target* for policy that is effectively communicated to the public, not necessarily an inflation target.

5.3. Unconventional Monetary Policy

In the aftermath of the recent financial crisis, central banks, especially those of advanced countries, were facing a new situation. Given the losses and financial turmoil that ensued, the solvency of many banks and borrowers were called into question. Consequently, the usually reliable relationship between changes in official interest rates and the market interest rates broke down. Moreover, even though some targets would have required a negative interest

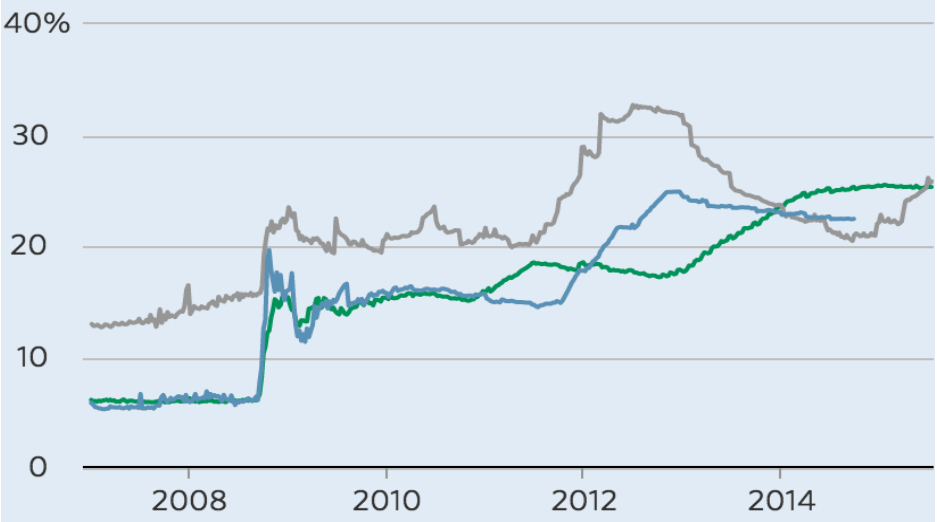
rate, nominal market interest rates are effectively limited by the zero lower bound, as market participants can always hold non-interest bearing cash (Joyce et.al 2012). The result was that conventional monetary policy proved ineffective. To aid the economy in its recovery to achieve price- and financial stability, central banks turned to so-called unconventional monetary policy. This type of policy can take many forms. Some commentators advocated suspension or changes to the inflation targets, while others promoted negative official interest rates. Nevertheless, the most common forms of unconventional monetary policy involved a massive expansion of central banks' balance sheets and attempts at influencing interest rates other than the usual short-term official rates. Any long-term interest rate can be decomposed into an expectations component that consist of the average of expected future short-term interest rates, and a term premium component (Wu 2013). Central banks have used "forward guidance" as a tool to influence the former. By publicly committing to keep interest low for a longer period than signaled by a traditional reaction function, central banks were trying to guide the market expectations of future short-term interest rates. The Federal Reserve, for instance, explicitly promised in August 2011 to keep its short-term interest rate exceptionally low "at least through mid-2013" (Wu 2013).

To provide sufficient liquidity and to influence the term premium component, central banks did also heavily expand their balance sheets. It was done through so-called Large Scale Asset Purchase (LSAP) programs, in which long-term government bonds and securities such as mortgage-backed securities were bought with newly printed money, or reserves, from the central banks. The securities are added to the central bank's assets on its balance sheet, while the reserves are listed as liabilities. Through affecting the supply-demand balance in the bond market, the central banks were aiming at lowering the term premium component.

It is safe to say that the central banks violated their duties as a Lender of Last Resort, laid out by Bagehot. They did lend freely and against, for the most part, high-quality securities, but they did not lend money at a high interest rate. The figure below illustrates the magnitude of the LSAPs conducted by Federal Reserve (green), Bank of England (blue) and ECB (grey).

Figure 3. Balance sheet assets as % of GDP

The graph in figure 3 presents the magnitude of the Large Scale Assets Purchases of the Federal Reserve in green, the Bank of England in blue and the ECB in grey. It is taken from Bloomberg´s website.[3]



5.4. Central Bank Independence

To give a central bank legitimacy and credibility among the market participants, the case for central bank independence has been generally accepted and practiced since the 1980s (Crowe and Meade 2008). The independence will, in theory at least, keep the central bank from acting as an extended arm of government by aiding it in financing deficits, lowering its debt burden through the creation of extensive inflation, or conduct expansionary policies with the purpose of helping an incumbent politician in getting re-elected. In fact, it has been showed that central bank independence reduces inflation (Crowe & Meade 2008). To state it another way, central bank independence seems to increase price stability. The government, however, often appoints the central bankers. This introduces a classic incentive problem from the governance field, where the central banker may feel he/she owes the appointer something, or fear he/she won't be re-elected for a second term if he/she does not give in to government pressure (Hermalin & Weisbach 2003). A further issue regarding central bank independence, and the loss thereof, has emerged in the aftermath of the financial crisis. Central banks, it is claimed, have digested the fact that they must help governments if they wish to avoid legal restructuring (Blancheton 2015). This help has taken the form of unconventional monetary

[3]www.bloomberg.com

policy, which eased the government's debt burden and postponed painful structural and fiscal reforms. When examining the independence of central banks and their relationship with governments, it is important to emphasize that this relationship is, after all, based on human interaction, where personality, expertise and other factors that are difficult to quantify affect the relationship.

PART III - Monetary Policy in Denmark

6. History of the Danish Monetary System

6.1. History

The Danish central bank, Danmarks Nationalbank, came into existence in 1818 as a privately owned company. Its establishment was seen as a direct response to counter the unstable monetary environment evident in Denmark at the time, and, as such, to regain the confidence of the currency among the population. As a matter of fact, ever since the first organized coinage system was established in 1020, the Danish people had been subject to a recurring debasement of the coins in circulation (Nationalbanken 2014). The coinage was based on silver and, just as in the Roman Empire, the governing authority saw the debasement as an opportunity to an easy and, initially, discrete source of income. The people observed and adapted to these inflationary initiatives, and even after Queen Margarethe I restored the coinage system in 1397, debasement of the coins nevertheless went on.

In 1713, paper money was introduced to the Danish money supply for the first time. The notes were supposed to have the equivalent value of the coins. However, the notes could not be exchanged into coins at demand. Once again, this time mainly due to the financing of the Great Northern War, the authorities issued paper money to the extent that the Danish people lost confidence in their value. Consequently, the notes were withdrawn from the Danish money supply in 1728. Then, in 1736, to support the growing Danish business community and its various transactions, Kurantbanken was founded. As a private bank with the monopoly of note-issuing, it is seen as the first Central Bank of Denmark. Besides being redeemable on demand into silver coins, the bank was not subject to any regulation or rules regarding its reserve backing of its bank notes issues called "kurantdaler" (Abildgren 2010). This convertibility, however, was suspended between 1745 and 1747 and again in 1757, this time

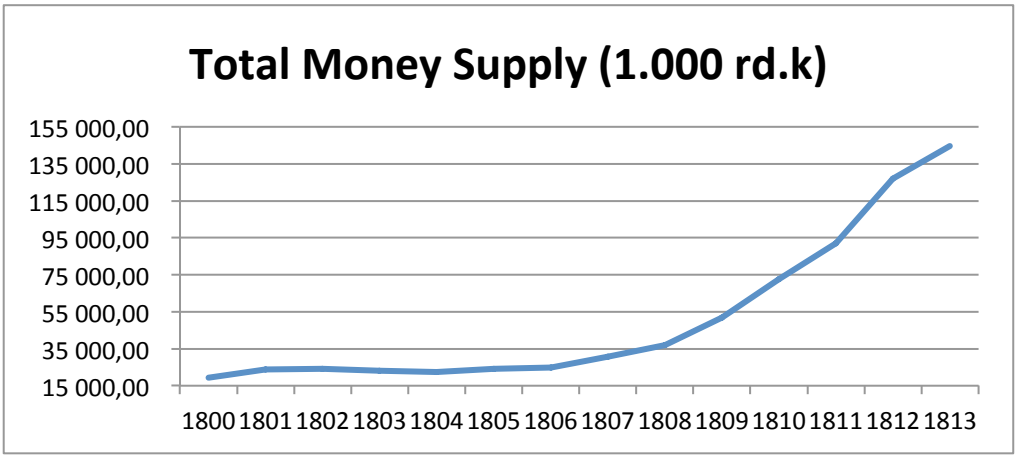
permanently, due to the excessive issuance of bank notes. The Danish population, then, were forced to use the notes as the means of payment. The bank was nationalized in 1773, which, conveniently, reduced the government's increasing interest payments to zero and at the same time increased its revenues through the bank's collection of interest payments (Svendsen 2010).

6.2. War-Inflation and the State Bankruptcy

During the summer of 1807, Denmark was whirled into the global conflict between France and Britain. Denmark was forced to join the French and its military leader, Napoleon, after Britain attacked Denmark, burned down Copenhagen and sailed away with the remaining Danish fleet (Feldbæk 2001) To cope with all the expenses that are associated with warfare, the government turned to the printing press. As can be seen in Figure 4, the money supply grew immensely during the Danish participation of the Napoleonic wars, from an initial supply of 30.549.000 kurantdaler at the onset of the war in 1807, to a total money supply of 144.762.000, including Danish treasury bills and Norwegian assignation certificates, at the end 1813 – an increase of nearly 375% (Svendsen 2010).

Figure 4. Total Danish money supply during the Napoleonic wars.

The graph in figure 4 below represents the total Danish money supply during the Napoleonic wars. It is measured in thousands of Kurantdaler, it is made from data obtained from Svendsen, 2010: Dansk Pengehistorie 1 – 1700-1818.



The Danish monetary system was ruined. As part of the necessary and comprehensive monetary reform of 1813, a new state-owned bank, Rigsbanken, was founded. It immediately replaced Kurantbanken and its privileges. An upper limit to notes in circulation was imposed, and all the existing Kurantdaler were to be converted to the new bank notes, Rigsdaler, at the ratio of 6:1 (Marcher 2010, p 137). The same ratio applied to government securities. Since the government found itself in a financial situation where it could not honor its obligations in terms of silver, the money reform has gone down in history as the "state bankruptcy".

6.3. Nationalbanken

The turbulence of 1813 had critically undermined the credibility of financial and monetary institutions in the eyes of the ordinary Danish citizen. In the following years, the value of the Rigsbankdaler fluctuated fiercely in terms of silver. As a result, another bank of issue, Danmarks Nationalbank, was established in 1818. It was given a royal charter that granted it a 90-year monopoly on note-issuing. Furthermore, Danmarks Nationalbankwas organized as privately owned joint-stock company outside government control. Still, it was legally obligated to uphold a stable monetary system and to ensure that Rigsbankdaler reached silver parity (Sørensen 2014). To reach this parity, the bank had to embark on a contractive monetary policy, which led the notes in circulation to be halved in the period 1818-1835. Also, Danmarks Nationalbankhad to resist the pressure from various groups complaining about the lack of credit. Even as the country suffered from an agriculture crisis and a subsequent recession in the 1820's, the bank kept on withdrawing notes from circulation. Eventually, this decisive stand bore fruit, when in 1838 the notes reached silver parity and, with it, confidence among the people (Marcher 2010). Indeed, silver parity was something the Danish people had not experienced since the suspension of convertibility back in 1757. Convertibility, however, was not reintroduced until 1845. Only after silver parity was reached did central bank actively take on the role as a commercial bank extending credit to benefit business and economic development. During the 1850's, at a time when the monetary system had proven its stability, other money- and credit institutions emerged. During the period 1854-1859, commercial banks, savings banks and credit associations increased their loans by 800%, 92% and 233%, respectively, while the loans of Danmarks Nationalbank decreased by 4% (Hansen 1972). The central bank, therefore, transformed into what is more associated with a present central bank, as it became the overall bank connection of the government and financial institutions. It was

also during this period that the central bank began to use the bank rate, or discount rate, as an active policy instrument to manage the demand for loans.

6.4. Gold and the Scandinavian Monetary Union

When Denmark's main trading partners, Germany and Great Britain, both had adopted a monetary system based on gold, Denmark also wanted a gold standard to replace the current silver standard. Again, Danmarks Nationalbank saw this as a stabilizing mechanism, one that would circumvent potential exchange rate volatility (Nationalbanken 2014). Moreover, a Scandinavian Monetary Union was fully established in 1875, with gold as its foundation. The Union's three countries shared a common unit of account, the krone, and a common circulation of the krone. This, too, can be seen to achieve stability within the Danish monetary system. Although it only lasted until the First World War, this Monetary Union, at its outbreak, was nevertheless one of the most far reaching of its kind.

In summary, prior to the creation of Danmarks Nationalbank, Denmark and its people were plagued by frequent instability in the monetary sphere. It all culminated with the state bankruptcy of 1813, which brought about an independent central bank dedicated to stability. Stability is the keyword, and, as we shall see in the next session, is at the core of current Danish monetary policy.

7. The Modern Danish Monetary System

As mentioned, in most countries, the primary objective of monetary policy is to maintain price stability. Denmark is no exception. Danmarks Nationalbank has a rich tradition for solving this issue through different fixed exchange-rate arrangements, starting with the aforementioned Scandinavian Monetary Union. The Danish krone was pegged to the British pound sterling during the 1930's. After the breakdown of the global Bretton Woods system in the early 1970's, Denmark joined the "currency snake" along with other European countries, with the intention of limit exchange rate fluctuations between them (Day 1976). Denmark later joined the European Exchange Rate Mechanism, the ERM, in 1979. The aim of this mechanism was to further reduce exchange rate volatility and monetary stability in Europe, and to prepare the European nations for the introduction of a single currency, the euro. Denmark officially pegged the Danish Krone to the Deutsche Mark in 1982; an arrangement that, with some devaluations of the krone, held up until the euro was launched. In 1999, with the euro in

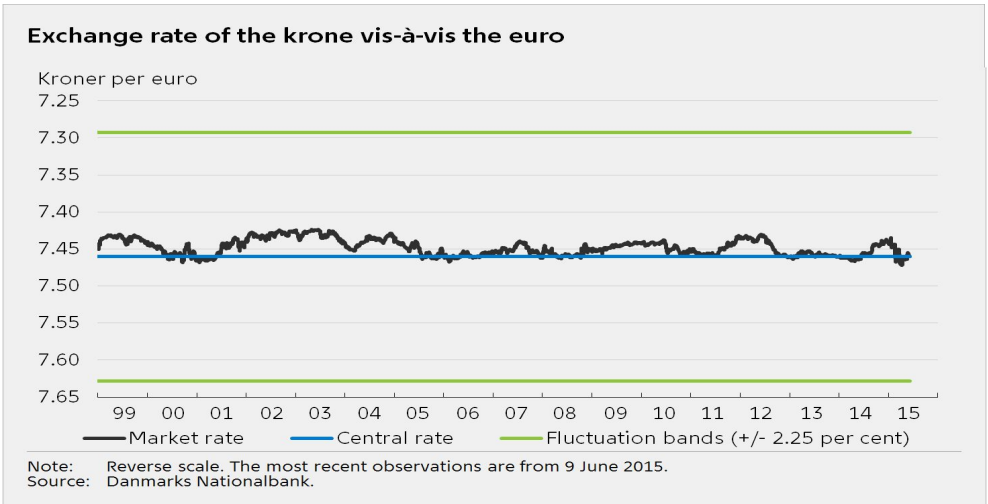
place, Denmark continued its currency peg engagement by joining the ERM II. Beside price stability, the Danish central bank's current main objectives are to guarantee safe payments and to ensure a stable financial system (Nationalbanken 2014). However, due to the scope of this assignment, these latter objectives will not be explored further.

7.1. Danish Monetary Policy

The ultimate aim of Danmarks Nationalbank is to achieve and maintain price stability. To reach this end, it has effectively pegged the krone to the euro through participation in the ERM II. The central rate, which is a conversion of the previous exchange rate against the Deutsche mark, is set at 7,46038 DKK per EUR. Within the ERM II framework, the standard deviation band is ±15%. But due to its high degree of convergence, Denmark reached an agreement with ECB to narrow the deviation band to ±2,25%. Yet, as Figure 5 illustrates, the exchange rate set by the market has never come close to either of the deviation bands.

Figure 5. Fluctuations of the EUR/DKK with respect to maximum allowed fluctuation band.

The graph in figure 5 depicts the historical fluctuations of the Danish krone and the euro between 1999 and 2015 in black. The blue line represents the official exchange rate, and the green lines the fluctuation band allowed by the ERM agreement. It is taken from the website of the Danmarks Nationalbank.[4]



[4] www.nationalbanken.dk

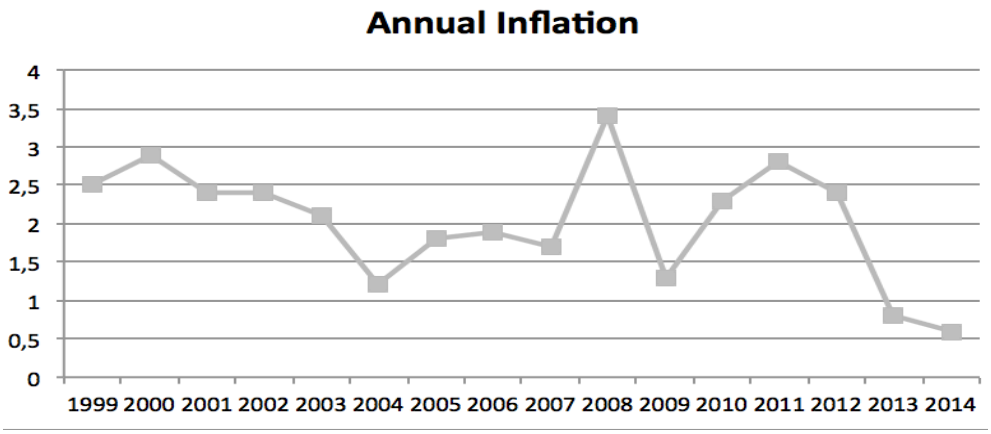
This dedication to preserve the peg means that other economic considerations, such as domestic unemployment and GDP growth rate, are not taken into account in relation to monetary policy (Nationalbanken 2009).

Since the European Central Bank has defined its objective as price stability, and furthermore defined price stability as a year-over-year increase in its preferred inflation index of below, but close to, 2% (ECB 2011), Danmarks Nationalbank has concluded that the peg will bring with it low and stable inflation in Denmark in the medium-to-long term (Nationalbanken 2009).

Judging by the figure below, there seem to be some validity to that claim.

Figure 6. Annual Danish inflation from 1999 to 2014.

The graph in figure 6 depicts the yearly Danish price changes, inflation, from 1999 to 2014. It is made using data retrieved from the Danish Statistical bank.[5]



7.2. Monetary Policy Instruments

Danmarks Nationalbank conducts monetary policy by setting the monetary policy interest rates, four of them in total, all short-term. They include a current-account rate, certificate of deposit rate, lending rate and a discount rate. These rates are set by the Board of Governors of Danmarks Nationalbank and may be changed at any time as required in order to sustain the fixed exchange rate and to ensure that the banking sector always has sufficient liquidity. In practice, the monetary policy is carried out via the lending and deposit facilities made available by Danmarks Nationalbank to banks and mortgage banks, often referred to as the

[5] www.dst.dk

monetary policy counterparties (Nationalbanken 2009). These counterparties have access to two facilities at central bank: *Current Accounts* and *Open Market Operations.*

7.2.1 Current Accounts

Each counterparty holds a current account at the central bank that accrue interest at the current account rate. Deposits in these accounts may, without notice and at the initiative of the counterparty, be used for transactions to or from another counterparty. As such, the current account deposits are therefore often referred to as liquidity or krone liquidity (Nationalbanken 2009). Furthermore, the accounts also function as a settlement account that facilitates lending and deposits between the central bank and its counterparties. The balance of the current account cannot be negative at the close of the day. Moreover, there is a limit put in the current accounts in order to prevent the build-up of large deposits that may immediately be used for speculation in interest rate and exchange rate changes if the krone is under pressure.

7.2.2 Open Market Operations

On the last banking day of the week, Danmarks Nationalbank conducts its open market operation. The counterparties can buy certificates of deposit, which they can also trade amongst themselves. The central bank also offers lending against securities in the central bank's collateral basis, primarily government- and mortgage bonds, in these operations. The deposits and collateralized loans accrue interest at the certificate of deposit rate and the lending rate, respectively, and typically have a maturity of 7 days.

The discount rate, the oldest monetary policy instrument controlled by Danmarks Nationalbank, is currently nothing more than a signaling rate that indicate the general level of monetary policy interest rates in Denmark (Nationalbanken 2009). All of the monetary policy rates have shown to strongly influence the money market rates in Denmark, which again are a significant determinant in capital flows and the DKK/EUR exchange rate (Nationalbanken 2009).

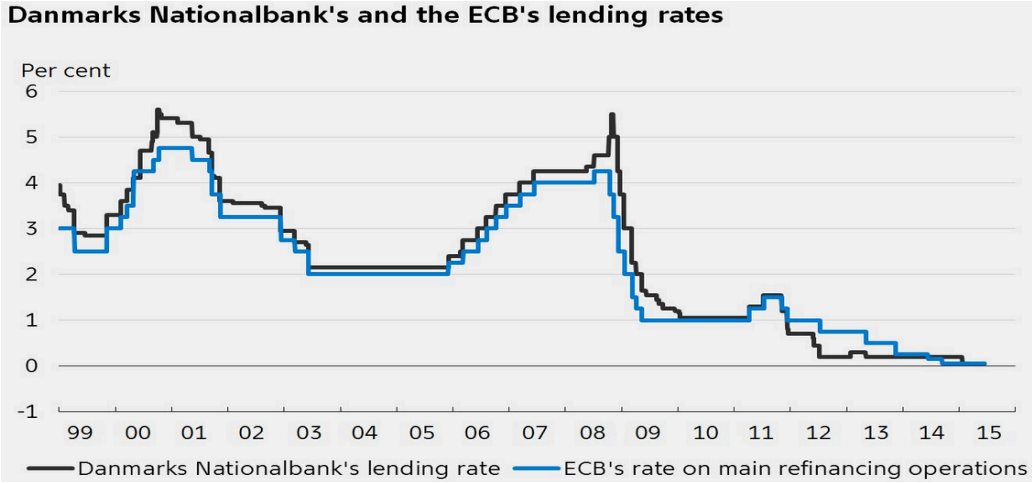
7.3 The euro-peg in practice

As Denmark doesn't operate with strict capital controls, and as the Mundell-Fleming Trilemma illustrates, Danmarks Nationalbank does not conduct an independent monetary policy. To maintain the peg, then, the Danish monetary policy follows the monetary policy of

the ECB, and only deviates when deemed necessary to keep the exchange rate within the given band (Fatum & Pedersen 2009). For instance, if the ECB changes its lending rate, the central bank of Denmark probably has to do the same, all else equal, to protect the peg. Figure 7 depicts this relationship.

Figure 7. The respective lending rates by ECB and Denmark´s central bank.

The graph in figure 7 represents the historical lending rates of the ECB in blue and Denmark's central bank in black. It stretches from 1999 to early 2015. It is taken from the central bank of Denmark´s website. [6]



However, if the Danish krone weakens or strengthens against the euro without there being an interest rate change implemented by the ECB, the first response of Danmarks Nationalbank will normally be to intervene in the foreign exchange market. If the krone is too weak, the central bank will buy DKK in exchange for foreign currency to strengthen the krone; if it's too strong, it will sell DKK in order to weaken it. Danmarks Nationalbank holds a considerable foreign exchange reserve for intervention purposes. If the exchange rate does not stabilize sufficiently and if this appears to be an enduring trend despite the intervention, the Danish central bank will unilaterally adjust its monetary policy interest rates. A continuous weakening of DKK, for instance, may force Danmarks Nationalbank to increase its monetary policy interest rates, which results in an increase in Danish money market interest rates compared to the euro area. In essence, this will make it more attractive to invest in Danish assets and thus raise the demand for DKK, effectively strengthen the currency. Also, if the DKK

[6] www.nationalbanken.dk

ever was to come close to its band limits, Danmarks Nationalbank and Denmark, as part of the ERM II, can receive help to stabilize the DKK/EUR from the European Central Bank.

Danmarks Nationalbank's determination to maintain the peg is well known among market participants. The graph in Figure 5 can be seen as a manifestation of the central bank's commitment. As a matter of fact, the credibility of the regime have led market participants to take positions that in themselves stabilize the exchange rate of DKK (Nationalbanken 2014). Beside a fixed exchange rate regime, independence from the state has been a traditional feature of Danmarks Nationalbank. Already back at its inception in 1818, great importance was attached to its independence. An independent central bank, it is assumed, will not be pressurized into implementing monetary policy that conflict with the objective of price stability. Today, Danmarks Nationalbank is independent from government, enforced through the Nationalbanken Act of 1936. In addition, the European Commission has concluded that this Act is in compliance with central bank independence as defined in the Maastricht Treaty (Nationalbanken 2009). In sum, Denmark's central bank's solid experience with fixed exchange rate regimes, independence, its decisive actions and past, present and future commitments, has contributed to credibility of the fixed exchange rate of DKK/EUR among market participants. Accordingly, Danmarks Nationalbank does not rely on "forward guidance" in forming market expectations to the same degree as other central banks do.

7.4. Why the Fixed Exchange Rate Regime?

To Danmarks Nationalbank, the euro-peg is the means to achieve domestic price stability. ECB has inflation target as its main policy, so practically, so does Danmarks Nationalbank. Recently, more and more central banks have adopted inflation targeting as their main objective. But as argued by Woodford (2003), it is more important for a central bank to have an explicit target for monetary policy that is communicated in an effective manner to the public, than an inflation target per se. The historical DKK/EUR exchange rate set by the market confirms that the Danish central bank has communicated its target policy adequately to market participants. In a historical context, Denmark has enjoyed a relatively low and stable inflation since the introduction of the euro. Stability, which further achieves confidence in a given currency, is crucial for trade and transactions to take place in an efficient manner. Price stability, or low and stable inflation, is also desirable due to the undesirable consequences of high inflation and deflation (Nationalbanken 2009). High inflation rates often

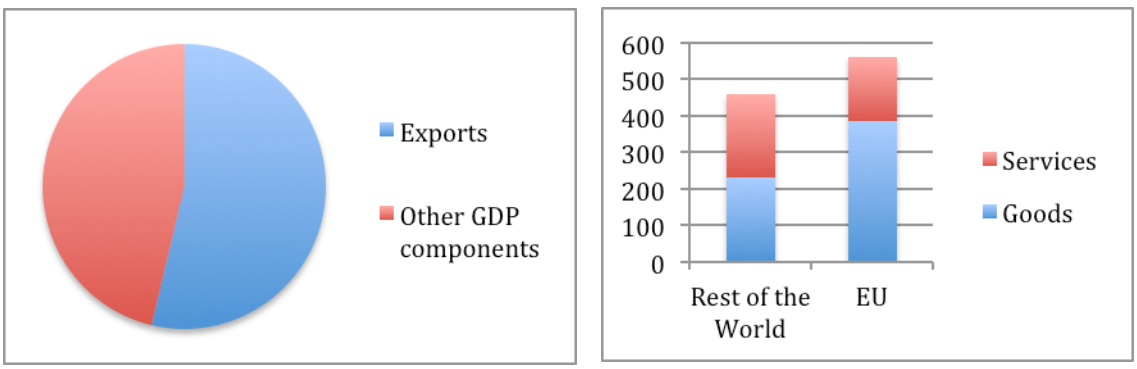
goes hand in hand with fluctuating inflation rates. Hence, uncertainty is greatly increased, and may cause the saving- and investment decisions by households and corporations to be sub-optimal, or worse. Furthermore, this uncertainty can prompt creditors to add risk premiums that, other things being equal, increase nominal interest rates, which may impede investment and economic growth. As inflation reduces purchasing power, high inflation can wipe out accumulated savings vital to investment. Deflation, on the other hand, increases the purchasing power. However, during a prolonged period of deflation, people are assumed to be reluctant to spend money because they believe prices will be cheaper in the future. The delayed purchases push down prices even more, and a deflationary spiral can unfold. Moreover, deflation increases the debt burden of households and companies. This can eventually lead to bankruptcies that can affect the solvency of banks to the extent that may threaten financial stability.

7.4.1. Foreign Trade

The fixed exchange rate can also be considered convenient regarding Denmark's foreign trade. Export is vital to the Danish Economy. During the years 2012, 2013 and 2014, export as a percentage of GDP has averaged at 54% in Denmark (World Bank 2015). According to the World Bank, using this measure, Denmark is ranked as 28 out of 137 countries. That is, for instance, a higher rank than Germany and Sweden obtained. More importantly, 55% of Danish export in 2014 ended up in EU countries (Danmarks Statistikbank 2015). Figure 8 and 9 portrays Denmark's export situation in more detail.

Figure 8 & 9. Charts depicting the distribution of GDP between exports and others.

The two charts below show the relative distribution of exports to total GDP. And their distribution between EU and other countries based on services and good. It is made from data retrieved from Denmark Statistical Bank.[7]



[7] www.dst.dk

The euro-peg, then, basically eliminates the exchange rate uncertainty between Denmark and the euro area. It should be noted, however, that both Britain and Sweden, who are among the top trading partners of Denmark, are EU members without having adopted the euro. Their trade with Eurozone members, including Denmark, is nevertheless substantial.

8. Unconventional Monetary Policy in Denmark

When the conventional monetary policy proved ineffective at the onset of the financial crisis, central banks across the globe embarked on unprecedented policies in order to provide liquidity to the financial market and to reduce interest rates of all maturities, which would further stimulate the real economy. These policies, better known as unconventional monetary policies, take many forms, as it is defined by what it is not rather than what it is (Joyce et al. 2012). Compared to larger central banks such as the Federal Reserve and the Bank of England, the Danish central bank did not launch any "Large Scale Asset Purchase"- programs, or Quantitative Easing, which has been considered the most common form of unconventional monetary policy in the aftermath of the financial crisis. Even as the European Central Bank initiated its own QE in January 2015, Danmarks Nationalbank obviously did not find it useful to launch any QE of its own to maintain the euro-peg. However, the Danish central bank has, we will argue, introduced two unconventional monetary policies in order to cope with the extraordinary situation within the monetary sphere brought on by the financial crisis and the subsequent European debt crisis.

8.1. Long-term Credit Facility

In October 2011, Danmarks Nationalbank expanded its range of monetary policy instruments to include a long-term credit facility. The monetary policy counterparties could raise 6-month loans against collateral on a monthly basis, starting Friday October 28th (Nationalbanken 2011). The central bank also expanded the counterparties' access its loans by including the counterparties' own credit claims as collateral. Danmarks Nationalbank estimated that this adjustment could possibly increase the collateral value by up to 400 billion DKK. Moreover, on December 8th, the Danish central bank mirrored the ECB and introduced the possibility of raising 3-year loans (Nationalbanken 2011). The loans were offered on two occasions: March 30th and September 28th 2012. Both long-term loans were to have a variable interest rate reflecting the official lending rate set by Danmarks Nationalbank. The 3-year loan would in addition be attached with an interest rate premium component starting July 31th 2013.

However, when this expiration date came due, the premium was never incorporated. Compared to the bank's traditional 7-day loan, these long-term loans, especially the 3-year loan, can be perceived as an extraordinary initiative by the Danish central bank to provide liquidity and to influence interest rates with longer maturities.

8.2. Negative Interest Rates

For the first time in its nearly 200-year history, Danmarks Nationalbank turned one of its monetary policy interest rates negative in July 2012. In connection with ECB's reduction of interest rate and an upward pressure on the DKK, Danmarks Nationalbank reduced the certificate of deposit interest rate to -0,20%. The interest rate returned to positive territory in 2013, before it was reduced below zero yet again in September 2014. At the beginning of 2015, due to ECB's QE announcements and a massive pressure on the DKK brought on by Switzerland's abandonment of its euro-peg, the central bank of Denmark was forced to decrease the certificate of deposit interest rate at four different occasions, reaching an extraordinary level of -0,75% on February 5th. The figure below depicts this interest rate from mid-2011 to early 2015.

Figure 10. Historical certificate of deposit rates from Danmarks Nationalbank.

The graph in figure 10 depicts the deposit rate of Danmarks Nationalbank bank from July 2011 to April 2015. It is made on data retrieved from Danmarks Nationalbank website.[8]

[8] www.nationalbanken.dk

Negative interest rates are quite unique in an international perspective as well, although it has occurred, even before the financial crisis of 07/08 (Jørgensen & Risbjerg 2012). In the 1970s, Switzerland, to counter appreciation pressure on the Swiss franc, introduced negative interest rates on non-residents' deposits at Swiss banks. Another example is the T-bill rate in Japan, which turned negative in 1998. Furthermore, short-term money-market interest rates in Germany, Switzerland and Denmark turned negative prior to Danmarks Nationalbank's negative interest rate, as market participants expected future interest rate reductions and due to the fact that these assets were considered a safe haven during times of financial instability in the euro area. Still, the only earlier example of negative monetary policy interest rates in recent times prior to Denmark's, was when the central bank of Sweden, Riksbanken, lowered the rate of interest on its deposit facility to -0,25% in July 2009 and kept it there for over a year (Jørgensen & Risbjerg 2012). However, the amount of deposits subject to this negative interest rate was very small, and the money-market rates stayed positive during the period. More recently, in second half of 2014 and early 2015, ECB, the Swiss National Bank (SNB) and Riksbanken all reduced their monetary policy interest rates below zero. But unlike Danmarks Nationalbank and SNB, which used negative interest rates to deter capital inflow and reduce the appreciation pressure on their respective currencies, ECB and Riksbanken did it to increase aggregate demand, as lower interest rates encourage consumption over saving, and lower the "hurdle rate" for investments (McAndrews 2015).

In academia, it has been argued that nominal interest rates are constrained by a zero lower bound. The reason is that market participants can substitute their deposits for cash, which yields a nominal interest rate of zero. Yet, in a practical aspect, holding large amounts of cash entails substantial costs (Jørgensen & Risbjerg 2012). These costs include storage, transportation and the insurance thereof. Further, it can be severely cumbersome to use cash for transactions involving considerable amounts or large geographical distances. Compared to its electronic equivalent, physical payment with cash can be rather time consuming.

When applied in Denmark, there was attached an element of uncertainty to what effects the negative interest rates would have throughout the Danish economy. The way they affected money-market interest rates was of particular interest, as they are a primary determinant in setting the DKK/EUR exchange rate. There was no indication that the pass-through from the monetary policy interest rate to the money-market interest rates was weakened (Jensen &

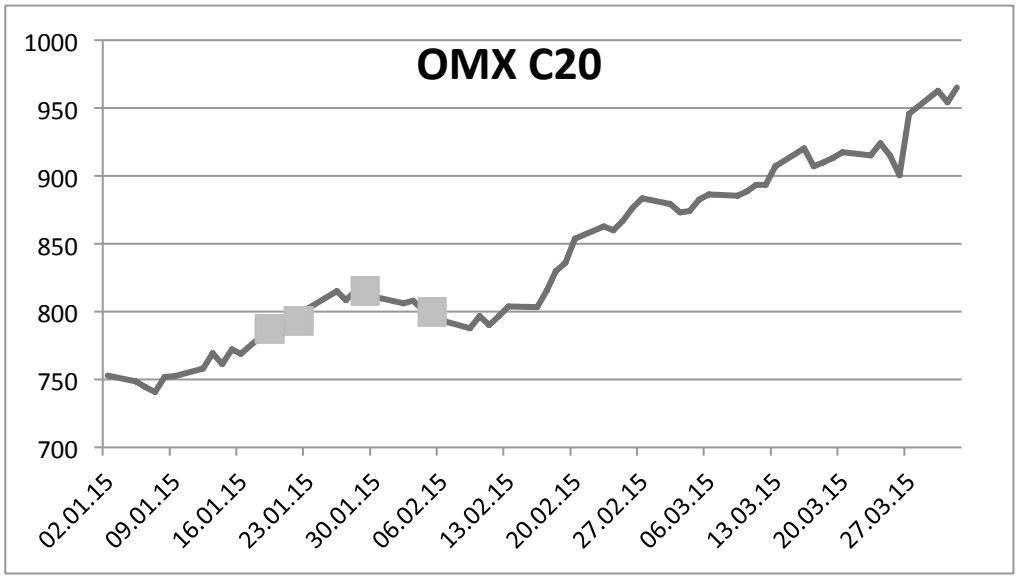
Spange 2015). The negative interest rates were not fully passed through to bank deposits to households, probably reflecting that some households would cash in their bank deposit. The storage and insurance costs seemed to outweigh the benefits. Also, if all banks did not introduce negative interest rates at the same time, costumers could be inclined to switch banks. The interest rates of larger deposits of firms and institutional investors, on the other hand, turned negative in the start of 2015 (Jensen & Spange 2015). The typical alternative for these costumers is to invest in the money market, which already suffered from negative interest rates. As such, they will be less inclined to withdraw their bank deposits relative to households.

In sum, the lower bound on monetary rates in Denmark is obviously lower than the rate on certificate of deposit of -0,75%. This bound may nevertheless shift if market participants expect the period of negative interest rates to persist.

Finally, there have been raised concerns that ultra-low and negative interest rates may contribute to a substantial and possibly unsustainable rise in asset prices. Whether they are sustainable, or even affected by monetary policy, stock prices in Denmark increased considerably during early 2015, along side four interest rate cuts by Danmarks Nationalbank from an already negative level. As Figure 11 illustrates, the OMX C20 index increased by about 30% following the interest rates reductions by Denmark's central bank, denoted by grey squares.

Figure 11. The historical evolution of the OMX Copenhagen 20 stock index in 2015.

The graph in figure 11 depicts the evolution of the OMX Copenhagen 20, an index of the 20 largest Danish companies. Thru January 2015 to the end of April 2015. It is made with data retrieved from Yahoo finance.[9]

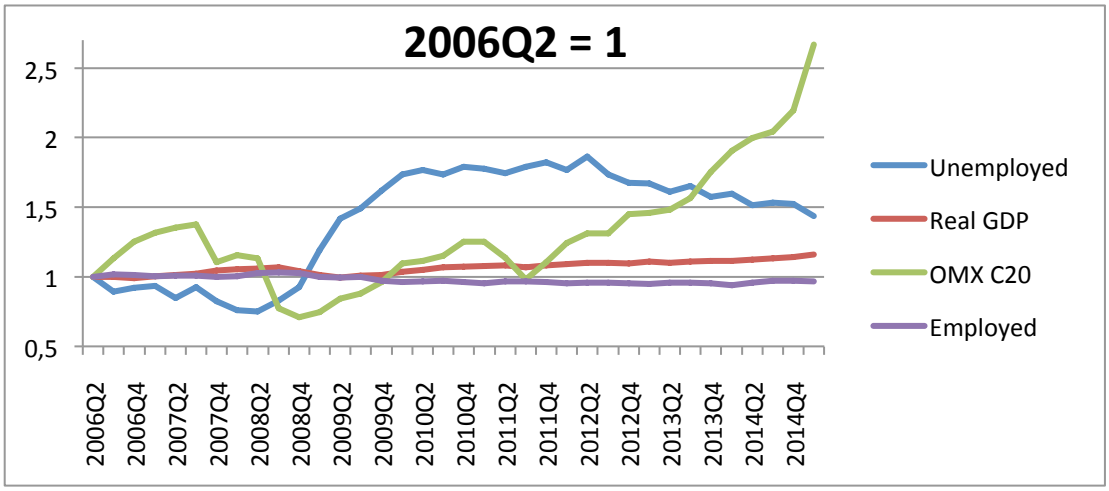


Furthermore, since the Danish stock market ideally should reflect the overall state of the economy, at least to some extent, the figure below depicts this decoupling in the most recent years.

[9]finance.yahoo.com

Figure 12. Historical evolution of a set of Unemployment, Real GDP, OMX C20 and employed.

The graph below depicts a set of diagnostic parameters of Danish economy from 2006 to late 2014. Namely; the Unemployment in blue, Real GDP in red, OMX C20 stock in green and number of people employed in purple. It is made from data retrieved from the Danish Statistical Bank.[10]



While the OMX C20 has nearly tripled since mid-2006, the employment situation is actually worse. Now, one must not put too much interpretation into this illustration. To compare real GDP- and employment growth with stock market growth, introduces a range of problems and considerations, for instance fiscal policy. Nonetheless, the recent surge in the stock market seems to stand out. Whether monetary policy had anything to do with it, will be addressed in our model. Unconventional monetary policy and equity prices will be elaborated on further in the next part of the assignment.

[10] www.dst.dk

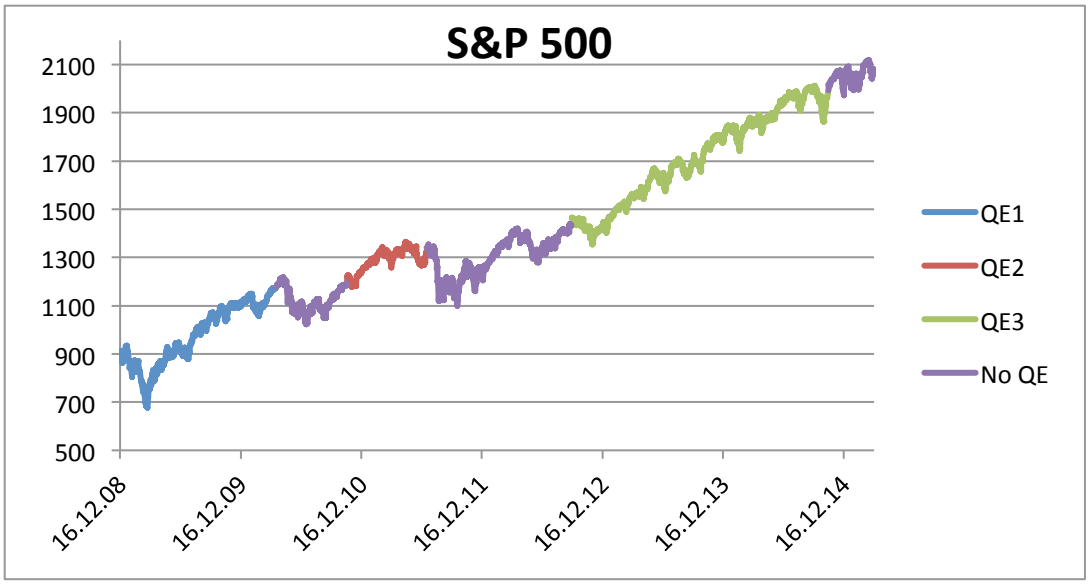
PART IV - Monetary Policy and Equity Prices

9. Unconventional Monetary Policy and Equity Prices

There have been some mixed findings regarding unconventional monetary policy's effect on equity prices, at least the initial effect. There are inflationary as well as deflationary pressures that accompany unconventional monetary policy announcements, which we will discuss in more detail next. Nevertheless, the Figure 13 depicts what happened to U.S equity prices during the periods of the three LSAP's conducted by the US Federal Reserve, at a time when the central bank had reached the zero lower bound.

Figure 13. Evolution of the S&P 500.

The graph in figure 13 depicts the evolution of the S&P 500 from end of 2008 till beginning of 2015. The different colors represent the duration of the QE´s implemented by the FED. The graph is created using data from Google Finance.[11]



As a matter of fact, Ben Bernanke, the former chairman of the Federal Reserve, noted that stock prices rose when investors began to anticipate QE2, and that "… higher stock prices will boost consumer wealth and help increase confidence, which can also spur spending" (Bernanke 2010). What he refers to is the wealth effect; as the value of your stock portfolio increase, so does your consumption. This increased consumption by equity owners will supposedly spread throughout the economy and set the stage for economic growth. In fact, a

[11]www.google.com/finance

study of the wealth effect conducted by Federal Reserve economists found that an extra dollar of wealth increases spending by about 3 cents, but that a one-dollar capital gain in equities increases spending by 19 cents (Juster et al. 2004).

10. The Case for Increased Equity Prices

10.1. Inflation

Whether a central bank is conducting an easy monetary policy by reducing interest rates to a certain level or expanding its balance sheet by a certain amount, in both circumstances it requires the central bank to increase the money supply by printing money. All else equal, this will increase the price of goods and services, including financial assets, as more money is chasing the same amount of goods and services. Furthermore, according to the Cantillion effect, initial recipients of the new money, the banking sector, benefit the most since they can use the money before its purchasing power is reduced (Cheng & Angus 2012). The banking sector is obviously closely connected to capital markets. By directing the newly printed money to these markets, the associated and, by then, uninflated prices are pushed higher. Only at a later stage, it is argued, does the new money spreads throughout the economy to end up with higher prices in general, reflected in inflation measures.

10.2. Present Values

Conventional economic theory states that the value of an asset is equal to the present value of its future economic benefits, most often referred to as the future cash flows it will generate. Due to the time-value of money, these cash flows have to be discounted by a discount rate that also take into account the risk associated with them (Petersen & Plenborg 2012). The traditional infinite dividend discount model, which almost all present-value models derive from, helps illustrate what could happen when a central bank lowers its interest rate.

$$Value\ of\ stock\ = \sum_{t=1}^{\infty} \frac{Div_t}{(1+r)^t} \quad , \tag{1}$$

where

Div_t = dividend paid in period t, and

r = discount rate.

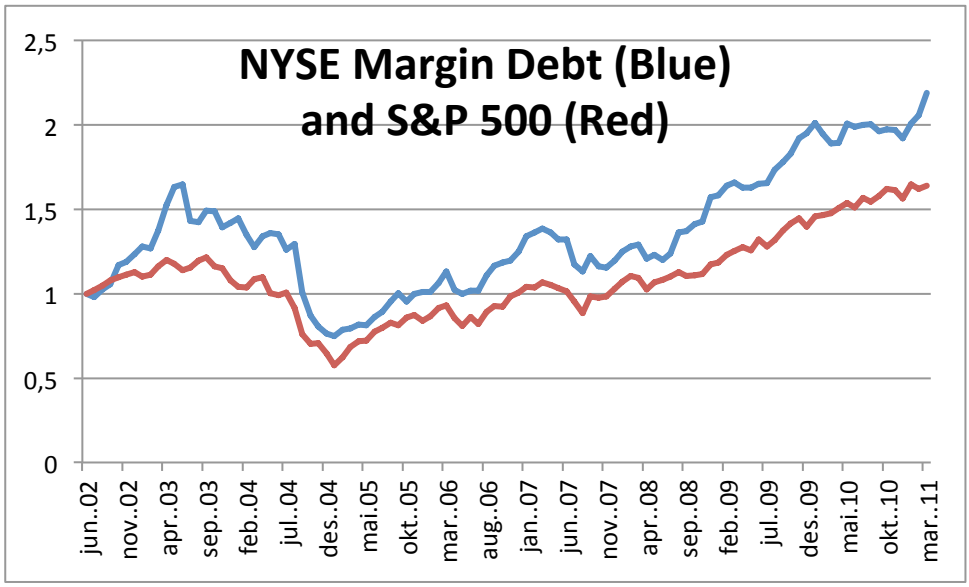
Again, the discount rate is not only determined by the time-value of money, but also, more importantly, by the risk associated with these particular cash flows. Stated differently, the discounted interest rate is the sum of a "risk-free" interest rate and a risk premium (Barsky & Bogusz 2014). It is this risk-free rate that central banks can influence. In economic textbooks, the risk-free rate usually corresponds to the yield on a high-rated government security. As the central bank lowers its interest rate, all else equal, the riskless interest rate is also, to some extent, lowered. Hence, the denominator in the equation above is decreased and the value of the asset is increased.

10.3. Risk-taking Channel

Another way a central bank can influence equity prices is through the "risk-taking channel" (Borio & Zhu 2012). This channel emphasizes the link between monetary policy and the perception and pricing of risk by market participants. Firstly, and related to present values, one set of effects operates through the impact of interest rates on valuations, incomes and cash flows. Lower interest rates boost asset prices as well as income and profits through lower financing costs and increased aggregate demand. This, in turn, can reduce risk perception and/or tolerance. The pro-cyclical estimates of default probabilities and volatilities, together with the common assumption that increased wealth increases risk tolerance, encourage risk-taking. Equity is, after all, a relatively risky asset. Moreover, a reduction in the interest rate leads to an increase in the borrower's net worth, reduces expected default probability and allows the borrower to take on more debt and expand investment. A kind of multiplier effect arises, since the boost to investment raises asset prices, further pushing up net worth and investments (Borio & Zhu 2012). Also, all else equal, lower financing costs should increase the use of margin debt, the amount of money stock investors have collectively borrowed via traditional margin accounts to funds stock purchases. The below figure, Figure 14, depicts this relationship, where July 2006=1.

Figure 14. Relationship between NYSE margin debt and the S&P 500 stock index.

The graph in figure 14 shows the evolution of the use of NYSE margin debt in blue, and the evolution of the S&P 500 stock index in red from June 2002 up until march 2011. The graph is made from data using the Yahoo Finance.[12]



Secondly, another set of effects operates through the relationship between market rates and target rates of return (Gambacorta 2009). Low interest rates may increase incentives for asset managers to take on more risks for contractual, behavioral or institutional reasons. For instance, life insurance companies and pension funds typically manage their assets with reference to their liabilities. These liabilities can be linked to a minimum guaranteed nominal rate of return or returns reflecting long-term actuarial assumptions. In periods of declining interest rates, they may exceed the yields available on highly rated government bonds, causing institutions to invest in higher-yielding, higher-risk instruments. When asset managers are pushed out on the risk curve this way, in the search of yield, it can put pressure on equity prices. In fact, back in 2013, the chairman of Danmarks Nationalbank, Lars Rhode touched upon this subject in a speech when he said:

"*... The danger, however, is that the current situation with very low nominal interest rates will persist for too long. It can encourage inappropriate risk-taking in the effort to achieve a higher return*[13]*."*

[12]finance.yahoo.com

11. The Case for Decreased Equity Prices

There are also some deflationary factors in play regarding unconventional monetary policy announcements' initial effect on equity prices. When a central bank announces an unconventional monetary policy to be implemented, it is not because it has gained a positive outlook on the current and/or future economic situation. Rather, it is the opposite. Since equity prices are supposed to reflect all public information affecting it, these easy monetary announcements should in effect signal lower future economic growth, and, if not expected by market participants, equity prices should be lowered as well, all else equal. More specific, going back to the discounted dividend model, the lower economic outlook could lower expected future dividends/cash flows. In addition, an increase in the risk premium in the discount rate can more than offset the decrease in the risk-free component. A decreased nominator coupled with an increased denominator, reduces the value of the stock. In fact, included in this context, there exists a debate on the causal relationship between information and monetary policy. If monetary policy is based upon previously known factors, then, it should not itself be unanticipated if all expected information is the basis for equity prices. This particular discussion is, however, outside the scope of this assignment.

More details regarding unconventional monetary policy and its effect on asset prices are giving in the Part V. The following section depicts recent valuations of Danish equities.

12. Danish Equity Valuations

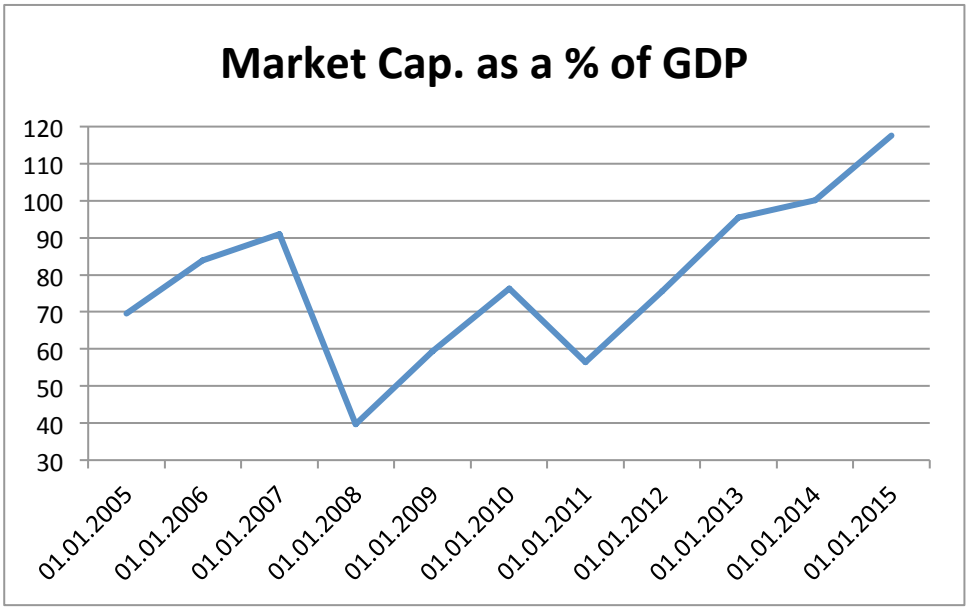
In this section we will not try to determine whether Danish equity prices are in a bubble or not. That is outside the scope of this assignment. We will, however, add a little perspective by briefly presenting some valuations of Danish equity throughout the period Q4 2005 till Q1 2015, using data extracted from Bloomberg Terminal.

To start, we present the combined market cap of Danish stocks as a percentage of Danish GDP in Figure 15.

[13] Lars Rhode'sspeech at Realkreditrådet'sannualmeeting, 26.09.2013

Figure 15. Danish total equity market cap as a percentage of GDP.

The graph in figure 15 presents the total value of all listed companies in percentage of GDP through the period 2005 to 2015. The data are given at year-end. The graph is based on data extracted from the Bloomberg Terminal at CBS. We were unable to retrieve data from later than Q4 2014, and created our own estimate, using the growth in equity prices of the three different market indexes, OMC C20 Cap, MidCap and SmallCap and the growth GDP[14] We averaged the growth in all three categories, and divided by the GDP after it had grown 0,4%.



In Q4 2014, Danish equity was more or less equal to the Danish GDP, or 100% of GDP. The last point on the graph, which is supposed to represent 31.03.2015, is our own estimate. We ended up at a rough estimate that increased by 17,5% percentage points during first quarter of 2015. Hence, the combined market capitalization of Danish firms equal 117,5% of Denmark's GDP as of March 31st 2015. At the last peak before the great recession, this estimate reached a little above 90%. The below table supplement the figure above.

[14] http://www.dst.dk/da/Statistik/NytHtml.aspx?cid=19109

Table 1. Danish market cap as percentage of GDP through time.

Table 1 is a list of the mean and average of the Bloomberg numbers for the Danish market cap as percentage of Danish GDP. The Q1 2015 estimate is our own based on calculations explained in figure 14.

Period: 2005-2015	Mrk. Cap as a % of GDP
Average	78,6 %
Median	76,4 %
Q1 2015*	**117,5 %**

Next, in Table 2, we have Denmark's combined market capitalization as a percentage of World's market cap.

Table 2. Denmark's portion of world market cap as a percentage through time.

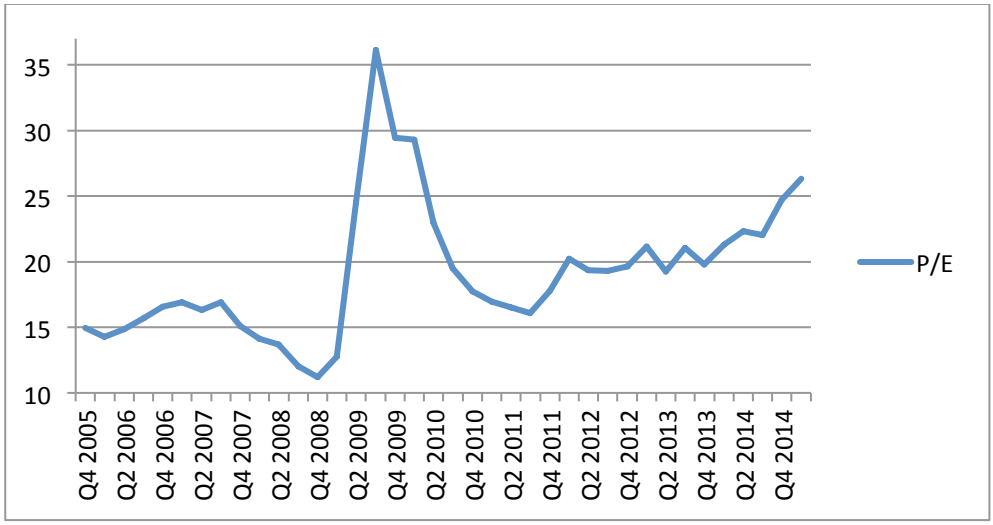
Table 2 lists the mean and average of the Danish portion of the world market in percent from 2005 up untilQ4 2014. It also includes the number for Q1 2015 in bold. All data are collected from the Bloomberg Terminal at CBS.

Period: 2005-2015	Denmark's Mrk. Cap as a % of World's Mrk. Cap
Average	4,71 %
Median	4,63 %
Q1 2015	**5,5 %**

Finally, we apply some more traditional valuation multiples to the OMX C20 index: Price-to-Earnings ratio, Price-to-Book ratio and Price-to-EBITDA ratio.

Figure 16. Historical P/E for OMX C20.

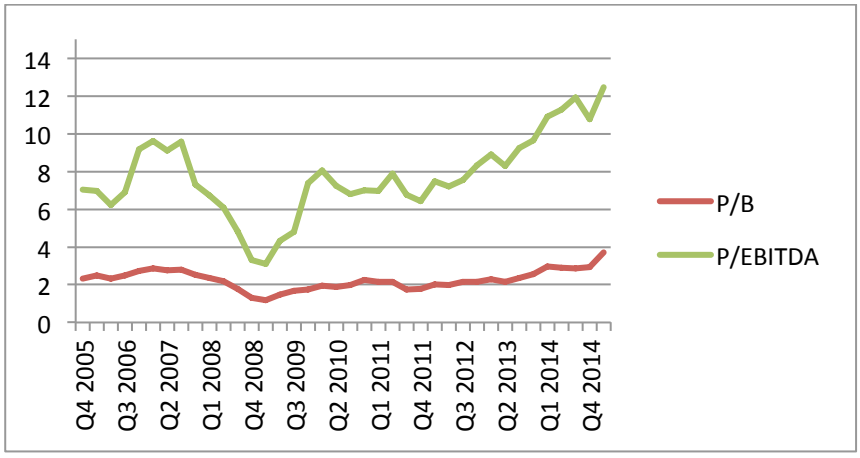
The table in figure 16 represents the historical evolution of the Danish market cap, OMX C20 from 2005 up until Q1 2015. It is made from data retrieved from the Bloomberg Terminal at CBS.



As can be seen from the P/E graph in figure 16, the most recent combined P/E ratio of the C20 companies is clearly above the average of the period, especially considering its post-crisis peak of 16,9 reached in Q3 2007. What may seem a bit odd about this graph is the one-year period starting in Q2 2009. The exceptionally high P/E ratio reached in this period is due to temporarily suppressed earnings, which is the denominator. Even including these somewhat useless measures, the P/E ratio obtained at the end of Q1 2015, 26,31, is far beyond the *average of 19,18.*

Figure 17. Historical evolution of P/B and P/EBITDA ratio.

The graph in figure 17 depicts the historical evolution of the price-to-book and price-to-EBITDA ratios of the Danish C20 from 2005 until Q1 2015. The graph is made from data retrieved in the Bloomberg terminal at CBS.



Turning to the P/B and P/EBITDA ratio, these are also evidently above the average. Moreover, both P/B- and P/EBITDA's most recent level of 12,46 and 3,7, respectively, are remarkably higher than their post-crisis highs of 9,59 and 2,81 from Q3 2007. Table 3 sums up the three multiples.

Table 3. Summary table of valuation ratios through time

In table 3 are listed a short summary of the different ratios introduced. P/E price earnings ratio, is the Price of equity divided by the profit. The price-to-book, P/B, is the price of equity divided with its' book value. Price/EBITDA is the equity price divided by the EBITDA. The data span from 2005 until 2015. The mean, median and the Q1 2015 values are listed. Data is retrieved from the Bloomberg terminal at Copenhagen Business School.

Period: 2005-2015	P/E	P/B	Price/EBITDA
Average	19,18	2,26	7,73
Median	18,51	2,23	7,35
Q1 2015	**26,31**	**3,70**	**12,46**

It is important to note, however, that our chosen time period does not exactly represent a usual time period regarding financial markets in particular, and economic life in general. The period does, after all, include the worst economic crisis since the Great Depression of the 1930s. Nevertheless, the valuations reached at the end of first quarter 2015 are noticeably high, not just compared with the averages and medians, but also compared to the post-crisis highs reached in 2007. Especially interesting are the developments taking place in the period Q3 2014 to Q1 2015, a period where Danmarks Nationalbank held the interest rate on its certificates of deposit below zero. In our model, we will address this relationship further. The relationship between unconventional monetary policy and asset prices in general, and the academic research thereof, is the subject of the next section.

PART V - Prior Research

13. Prior Research

The conventional wisdom, during a period of conventional monetary policy, is that a tighter monetary policy depresses stock prices, all else equal (Ivrendi & Pearce 2014). Also, in their famous paper regarding conventional monetary policy, Bernanke & Kuttner (2005) finds that an unanticipated reduction of the federal funds rate by 25 basis points, increased stock prices with 1%. On the other hand, as mentioned earlier, there still has not been reached any broad consensus among economists regarding the impact of unconventional monetary policy, nor through which channels it works. There are several reasons why this may be the case. Firstly, economists differ in general, not just on monetary policy, with economists ranging from marxists at one end of the specter, to anarcho-capitalists at the other, with a number of different schools of economic thought filling the gap. Secondly, economics is a social science that essentially is trying to explain human actions and incentives. Unlike a laboratory experiment, there are a lot of different factors that affect each other, and may be immensely difficult to isolate. To prove a correlation is one thing; to do the same with causality is an entire different matter. The unpredictable element and heterogeneous preferences found in human behavior pose a big challenge to anyone who tries to quantify it. Moreover, as there are boundless ways to set up and select inputs in economic models, outcomes will naturally vary. Economist Ludvig von Mises takes this point to the extreme when he states:

"All monetary policies encounter the difficulty that the effects of any measure taken … can either be foreseen in advance, nor their nature and magnitude be determined even after they have already occurred." (Mises 2009)

Thirdly, and as the name imply, unconventional monetary policy lack historical evidence and thus historical support. These monetary experiments, embarked on by central banks across the globe since the outbreak of the financial crisis, are unprecedented by any standard. Yet, it may be too soon to pass judgment on these policies since effects may be lagged. Only time will tell. It is nevertheless difficult to circumvent the fact that the economic recovery in the Western world has been sluggish. Still, a global bull market in equities and a significant drop in bond yields have both coincided with these extraordinary central bank actions since early 2009.

Without going into too much detail, we will provide results from some of the vast research addressing unconventional monetary policy and its impact on bond yields and stock markets.

13.1 Unconventional Monetary Policy on Bond Yields

13.1.1. Wright 2012: "What does monetary policy do to long-term interest rates at the zero lower bound?

Jonathan Wright (2012) identified days on which the variance of monetary policy shocks was especially high, during the period when the FED had reached the lower zero bound. After identifying 28 "announcement days", he then goes on to measure how these monetary policy shocks influenced Treasuries, corporate bonds and equity markets by using a structural VAR approach. The identified monetary policy shock is normalized to immediately lower the 10-year yield and the 2-year yield by 25 and 10 basis points, respectively. Wright further finds that the BAA and AAA corporate bond yields fall about the same as the 2-year Treasury. The AAA yield decrease has, not surprisingly, a much tighter 95% confidence interval than the BAA yield decrease. In the second part of the paper, Wright uses an event-study methodology and intraday data on the announcement days to investigate the same objective. By computing the monetary policy shock as the first principal component of the yield changes from 15 minutes prior to the announcement to 1 hour and 45 minutes afterwards, rescaled to have a standard deviation of 1, Wright estimates that a one standard deviation monetary policy surprise lowered the 10-year treasury with 12 basis points. The two-year treasury, however, falls by 6 basis points. Both AAA and BAA fall by about 7 basis points. Moreover, he finds that 10-year Canadian, UK and German yields fall by 5, 4 and 3 basis points, respectively.

13.1.2. Guidolin et al. 2014: "Unconventional monetary policies and the corporate bond market"

The authors found that, using data from 2004 to 2012 to construct bond portfolios, a conventional monetary expansion caused an increase in corporate bond yields –and spreads. More surprisingly, they found that corporate yields increased following QE. The authors attribute this phenomenon to higher inflationary expectations and a signaling effect, as a monetary expansion is a result of a present and/or future economic slowdown. These two factors are believed to offset any direct impact. The effect was, however, modest and not significant for investment grade bonds.

13.1.3. Rivolta 2014: "AN EVENT STUDY ANALYSIS OF ECB UNCONVENTIONAL MONETARY POLICY"

Rivolta (2014) analyzes the impact of the unconventional monetary policy measures implemented by the ECB since 2007 to cope with the financial and sovereign debt crisis. He uses an event-study methodology to measure the impact of the extraordinary liquidity injections on sovereign bods yields of 10 European countries. He finds that the effects vary between countries and time. Before the onset of the sovereign debt crisis in Europe in 2010, the liquidity injections led to a significant and progressive decrease in bond yields across Europe. After the liquidity crisis had evolved to a sovereign debt crisis, the spreads of highly indebted countries increased. For instance, when ECB announced its LTRO with a 36-month maturity at the end of 2011, investment-grade countries yields was reduced significantly while Italian, Spanish, Greek and Portuguese yields increased, whereas the two latter of high statistical significance.

13.1.4. Fratzscher et al. (2014) "ECB Unconventional Monetary Policy Actions- Market Impact, international Spillovers and Transmission Channels"

Fratzscher et al. (2014) measures the effect of ECB unconventional monetary policy announcements on two different groups of European countries: the highly rated countries of Finland, Germany, Austria and the Netherlands in one group, and Spain and Italy, who experienced sovereign tensions at the time, in the other group. They focus on announcements that were covered on the front page of Financial Times on the following day. The authors estimated that without these extraordinary policies, the yields of Spain and Italy would have been about 300 basis points higher in September 2012, while they only would have been 5 basis points higher for the high-rated countries. Hence, ECB effectively reduced the bond spreads between countries within the Eurozone.

13.1.5. Krishnamurthy & Vissing-Jørgensen (2011): "The effects of quantitative easing on interest rates"

By using an event-study methodology that exploits both daily and intra-day data on announcements regarding QE1 and QE2, Krishnamurthy & Vissing-Jørgensen (2011) find a large and significant drop in nominal interest rates on long-term safe assets. They claim this occurs mainly because there exists a unique clientele for long-term safe assets, and the Fed purchases reduce the supply of such assets and hence increase the equilibrium safety-

premium. On less safe assets such as Baa corporate rates, on the other hand, they find smaller effects attributed to the reduction in the default- and prepayment risk premium.

13.1.6. IMF 2014: "Unconventional Mon. Pol. and Long-term interest rates"

Tao Wu, an economist who works for IMF, also examine the channels through which unconventional monetary policy has worked. He finds that the LSAP has effectively lowered the long-term Treasury bond yields, through both "signaling" and "portfolio balance" channels. The continuing LSAPs help to enhance the credibility of forward guidance and guide the market's expectations of future short-term interest rates; hence the signaling effect. The LSAPs, it is believed, affect financial conditions by changing the quantity and mix of financial assets held by the public; hence the portfolio balance effect. When the central bank purchase a particular security, the supply of this security will be reduced and investors will simultaneously look for securities with similar characteristics.

13.1.7. Others

Turning to UK, Meier (2009) found that the initial QE announcements by the Bank of England reduced gilt yields by 35-60 basis points. Moreover, Joyce et al. (2011a) estimated that medium-to-long-term gilt yields fell by 100 basis points by summing up the two-day reactions to the first round of QE announcements during 2009 and 2010.

On another note, Curdia & Woodford (2011) argue that the reason that QE has been ineffective because reserves/money and government bonds had become perfect substitutes. Swapping one for another, LSAP, does nothing. Kiyotaki & Moore (2012) uses a model where financial assets differ in their liquidity. When a liquidity shock appears, then, the central bank can purchase the less liquid assets for newly created money. Thus, limited participation and imperfections in credit markets are at the heart of their model and explain why the neutrality result of Curdia and Woodford don't hold.

13.2. Unconventional Monetary Policy on Equity Prices

In the same paper that is mentioned above, Wright also investigates the effect of unconventional monetary policy announcements on equity prices. More precisely, he finds that a monetary policy surprise that lowers the 10-year treasury is estimated to boost US stock returns by over half a percentage point. Wright further finds that return on small stocks minus return on big stocks factor, or the SMB factor of Fama and French, was not significantly

affected. Thus, size did not seem to be a priced risk factor in the stock market. However, the monetary policy shock significantly increased the HML factor, or returns on value stocks minus return on growth stocks, by a little less than half a percent.

13.2.1. Bernanke & Kuttner 2005 "What Explains the Stock Market's Reaction to Federal Reserve policy?"

Bernanke & Kuttner uses FOMC meetings as events and Federal Funds rate futures to represent changes in monetary policy to find that; under conventional monetary policy, they estimate that, before the zero lower bound was reached, an unanticipated 25 basis point surprise reduction of the federal funds rate raised stock prices by about one percent. If market participants anticipate the rate change, on the other hand, they estimate that the market reacts little, if at all. They also find that the magnitude of change in the stock prices depend on the industry, high-tech and telecommunications exhibiting the largest responses to unanticipated changes in monetary policy.

13.1.3. Glick and Leduc (2012): "Central bank announcements of asset purchases and the impact on global financial and commodity markets"

Glick & Leduc (2012) estimates the effect LSAP announcements by the Fed and Bank of England has on equity markets. After they divided up the announcements, into positive or negative surprises, or looser and tighter monetary policy, respectively, they found, to their surprise, that a positive surprise tended to depress equity prices, while negative surprises tended to boost them. Moreover, they reached the same conclusion regarding commodity prices. These results, the authors conclude, can be interpreted as a priori support for the signaling effects of LSAP announcements. Hence, the announcements signaled more pessimistic economic conditions to market participants.

Fratzscher et al. (2014), a paper that is mentioned in the former section, also found that without the unconventional monetary policies conducted by the ECB, equity prices would be 10 percentage points lower for both subgroups at the end of September 2012.

PART VI - Analysis

In this part of the assignment, we explain our models, how they are constructed and the inputs used. We start by explaining the indexes we use to look at different equities.

14. Indexes

In Denmark, there is limited access to historic prices of industry-segregated indexes. However, getting a hold of share prices historically is somewhat simple. We therefore decided to create our own indexes. More specific, we decided to take a look at two different industries. We take a look at the pharmaceutical industry and banking sectors of Denmark. The pharmaceutical industry is interesting because of two reasons. Firstly, it is by export the second biggest industry in Denmark. According to Medwatch[15] and DST[16], almost 11% of Danish export in 2012 came from the pharmaceutical industry, putting it only second to agriculture. Secondly, Novo Nordisk is the largest company in Denmark by market cap and thus the main driver for the C20 and the reason why C20 potentially does not exactly match the evolution of the Danish equity prices. It would therefore be beneficial to examine this industry further.

The second industry we created an index for is the banking industry. In order to comment on interest rate channels, discussed in the channels chapter, we need to look at the difference between the effects from interest rate changes on small and large banks, e.g. the monetary "counterparts".

The indexes are simple averages of historic prices and will not take market cap into consideration, besides the initial separation. We are interested in the average change of the price of each share on event days in the model that we have set up. However, because there is such a significant difference in the price of each company's share, the changes would be completely dominated by the expensive shares. Instead of taking a simple average of the prices and then calculating the change, we therefore calculate the %-decrease/increase on each day and average these out. This will weigh the smaller companies, which have larger standard deviations on price changes, proportionally too much. We could account for this by then dividing with the standard deviation. In the banking sector, we want to look at the difference between small banks and large banks. Fortunately, they have very similar standard

[15]http://medwatch.dk/Medicinal__Biotek/article6161380.ece
[16]Denmark's statistical Bureau, Danmarks Statistik Bank - www.DST.dk

deviations within their size index so this poses no problem. We proceed by also dividing the pharmaceutical industries into Biotech and Pharmaceutical, to account for the same variation in Standard deviation. A biotech company is a company that doesn't have any products yet, but are going through the process of proving their candidates. Differently, the pharmaceutical companies have products in place that already earns money to pay for development; the latter is a much less risky investment.

Underneath we show the mathematical construction of the banking index. We start off by finding the percentage change on the event days.

(2)

$$JyskeBank_{eventday\ 1} = \frac{P(Shareon\ \ 25-03-2015) - P(Shareon\ 24-03-2015)}{P(Shareon\ 24-03-2015)} \ldots.$$

This is done for all three banks listed on the Copenhagen Large Cap: Jyske Bank, Danske Bank and Nordea.

The index itself is then just a flat average between these three daily changes.

(3)

$$Index_{eventday\ 1} = \frac{1}{3} \cdot JyskeBank_{eventday\ 1} + \frac{1}{3} \cdot DanskeBank_{eventday\ 1} + \frac{1}{3} \cdot Nordea_{eventday\ 1}$$

The midcap banks we used as the small bank index were: Ringkjøbing Landbobank, Alm Brand, and Jutlander Bank. We realize that Alm brand is also an insurance company, but due to lack of alternatives in the midcap sector we were forced to use it.

We did the exact same calculations using the pharmaceutical shares. The pharmaceutical shares are; Novo Nordisk, H. Lundbeck, and Coloplast. Coloplast is not a producer of medicine, but rather a manufacturer of life science products such as Ostomy bags etc. For small biotech companies we used the prices of: Veloxis Pharmaceuticals, Zealand Pharma, and Genmab.

There is no weighting towards market cap besides the overall separation between small and large banks, biotech and pharmaceutical company.

15. Channels:

In every economy there is a real long-term interest rate utilized by the market. In every economy the central bank is trying to influence this real interest rate on behalf of some goal such as a peg or inflation target. In Denmark the goal is clearly stated on the front page of Danmarks Nationalbank.

ECB uses monetary policy, loose or tight, to keep the inflation at target. In the later years the euro area has had a problem with low inflation in many of its member countries and therefore it has chosen to increase money supply through its own quantitative easing program. The increased money supply devalues the euro against other currencies. When the euro devalues it puts pressure on the Danish krone and the NB will have to change the attractiveness of the Danish krone. (Jørgensen & Risbjerg 2012) Besides the risk-taking channel mentioned in a former section, we will be looking at the two channels mentioned underneath and comment upon them in our secondary results.

15.1. The interest rate channel

These NB rates are used by a select number of banks in Denmark that function as the "monetary political counterparties" (Drejer et al. 2011). The NB monetary policy interest rates function as alternative rates to real rates in the economy, such as the money market, and therefore have a certain influence on real market rates such as: household debt, corporate debt, and the Treasury bonds.

Drejer et al. (2011) test for the existence of such a channel by looking at the co-movements of changes in NB rates and the rates that banks offer their customers. They find that before the crisis roughly 98% of changes were transferred into the market interest rates, but note that this has gone down after the crisis, and hypothesize that this is due to liquidity constraints. As mentioned earlier, the NB rates are only accessible for larger institutions and if the alternative interest rate hypothesis is true, there will be a difference in the impact of NB rate changes between large and small banks.

To test if this is the case we will in our model look at the effect of changes in Danish Treasury bond rates on large and small listed banks.

15.2. The credit channel

In the paper by Askjær et al. (2011) they separate the credit channel into two different channels; “bank borrowing channel” and “the balance sheet channel”.

The bank borrowing channel affects the bank’s ability to lend money to households and companies. An interest hike will lead to increased losses and accruals on loans and reduce the value of the bank’s assets. In order to test this channel we would need to compare different bank characteristics across different banks. This is out of the scope of this assignment and will therefore be left untested. They do not find any proof of this channel in their paper.

The balance sheet channel is the idea that debtor takes a loss on asset value following an interest hike. This affects their ability to put collateral for their loans. This will make banks less willing to lend out money. According to Drejer et al. (2011), this will make debtors that have difficulty obtaining creditworthiness less likely to receive loans. They do not explicitly test this due to data constraints but follow up by commenting on the spread between interest paid on loans to large companies and small companies. They find that it has increased since the recession. However, at the height of the boom, just before the crash in 2008, the spread was abnormally small. They explain this by hypothesizing that the banks were looking for returns and, therefore, cared less about credit ratings. We will test a variation of the same method in this paper and comment upon it in our secondary results.

16. Data:

16.1. Bonds

In this paper we use three different types of "main" data. The Danish Treasury bond "Statsobligationer", the Danish interbank borrowing rate "CIBOR" and different stock prices and indexes.

The Danish Treasury bonds, named Statsobligationer, are retrieved from the Bloomberg Terminal at the Copenhagen Business School library. They come in different maturities, of which the most dominant is the 10-year maturity when measured on volumes traded. The information we were able to gather from Bloomberg is significantly fragmented, and several important days had missing values for a number of the different maturities. We ended up

deciding to only use 1-, 2-, 5-, 10- and 30-year maturities, as they were the maturities with the most observations available. The total number of possible event observations using Treasury bond data is 89. We, in some of the models, add additional data to the 2-, 5- and 10 year Treasury bond rates up to a maximum of 109 observations. We were able to get additional data on these three maturities from the Statistical Bank of the Danmarks Nationalbank.[17]

The interbank lending rate, CIBOR, is released every bank day at 11am. It is an average of the interest rates that the largest banks in Denmark are willing to lend to another bank, without collateral, for a specified maturity. In our dataset, the maturities range between three to twelve months. The data is retrieved from Nasdaq who get the data from Finansrådet every day.[18][19]

The CIBOR data is quite intact and we could use all the different maturities on all the days we were interested in examining. The total number of observations given event days and data availability amounted to 122 observations.

16.2. Equity prices

The stock prices are, beside Bloomberg Terminal, also retrieved from Nasdaq, who operates the Copenhagen Stock Exchange.

OMX Copenhagen 20 index, in short C20, is used throughout this paper. It is a representation of the value of the 20 largest Danish public companies. A new index has recently been created called C20 Cap. Due to being established in the middle of 2011, it is not a very useful as a representation of the value of Danish stocks in our analysis, since our data on interest rates go back to 2005. We therefore chose to use the "older" C20 to represent the value of the largest Danish companies. This has the disadvantage that it is heavily based on the share price of the largest company in Denmark, Novo Nordisk A/S. Due to its incredible growth over the last decade, it has come to be so valuable that it affect the evolution of the C20 unrepresentatively much. We try to minimize this problem by comparing to other stock indexes such as Midcap and SmallCap, and by accounting for the relationship between interest rates and the pharmaceutical business. However, it is still an obvious disadvantage.

[17]http://nationalbanken.statistikbank.dk/statbank5a/default.asp?w=1920
[18]http://www.finansraadet.dk/Tal--Fakta/Pages/satser/regler-for-fastlaeggelse-af-cibor/dagens-satser.aspx
[19]http://www.nasdaqomxnordic.com/

16.3. Events

The events used are listed in the Appendix 3. They all constitute available information gathered from the ECB, Federal Fund Reserve and Danmarks Nationalbank. The events based on information gathered from the US are not included in the full model. However, all other events are. The total number of events is equivalent to the full number of CIBOR observations 122, since there was no reduction due to data unavailability in the CIBOR model. They have been gathered from different sources. The ECB event days are what we consider to be the most important announcements to be found in press conferences, public statements etc., all found on ECB's own webpage.[20]Danmarks Nationalbank events include all interest changes, speeches and all quarterly press releases. This data has been gathered from the Danmarks Nationalbanks' own website.[21][22] The Federal Reserve events are all press releases regarding its unconventional monetary policies.[23]

16.4. Miscellaneous

In addition to these three types of main data used in our result part, we have used additional data from various sources for creating models throughout the assignment. These are:

- Equity prices from Yahoo Finance.[24]
- Numbers on export and GDP from Denmark's Statistical bank.[25]
- Equity prices and specifications from Google Finance.[26]
- Data on the Danish trade balance and trade partners from IMF.[27]

16.5. Limitations:

There were some gaps in the completeness of the data obtained using the Bloomberg Terminal. We realize that this might have an effect on our results. Missing events with a large effect on the Treasury bond rates could skew our results and thereby interpretation. We managed to get data throughout the entire period of interest, which leads us to believe that despite missing potentially important events, the results remain useful. Another factor that would support this claim is the fact that Wright (2012) had 28 observations; Bernanke &

[20]http://www.ecb.europa.eu/press/html/index.en.html
[21]http://www.nationalbanken.dk/en/pressroom/Pages/default.aspx
[22]http://www.nationalbanken.dk/en/statistics/Pages/default.aspx
[23]http://www.federalreserve.gov/monetarypolicy/default.htm
[24]http://finance.yahoo.com/
[25]http://www.dst.dk/da/Statistik#6
[26]http://www.google.com/finance
[27]https://www.imf.org/external/pubs/nft/2014/areaers/ar2014.pdf

Kuttner (2005) used 131 observations, while we have 122. Wright (2012) based his events on a test for days with large heteroscedasticity. He was able to do this because he had access to intraday data. We believe that the fact that we incorporate 122 observations should be enough to mitigate any effect that lacking events would pose. Furthermore, intraday data would have made us able to better isolate the causal effects between equity prices and monetary policy, mainly because the larger the lag, the harder it is to isolate cause and response. This is especially true when considering the fact that Denmark is a small and open economy that is influenced by many factors worldwide. Moreover, we have not accounted in our model for the general economic environment or inflation adjusted data despite adding recession dummies. Inflation is not EU-wide, and varies from country to country, which could create a difference when comparing bonds from different countries. However, since inflation has remained relatively low through the period of research, we believe the effect to be negligible. We also did not differentiate between expected and unexpected information as Bernanke & Kuttner (2005) did. We do, however, include a chapter that discusses outliers and their causal relationship to the equity prices. The outliers that created a shock to the Treasury bonds rates of ±1,5 standard deviations should, in theory, equate to unanticipated events.

17. The model:

We use a regression model to compare the daily changes in interest rates to equity prices in the form of stock indexes. We mainly use Treasury bond rates, but also to some extent utilize the CIBOR rates. The daily changes are measured on event days, except when event days are based on news from the Federal Reserve. The event days have been discussed and qualitatively selected in a previous chapter. We did not have access to intraday data. If we had had access to intraday data, we could have made an analysis on the heteroscedasticity in variance across different days, assuming like Wright 2012 that event days are heteroskedastic, or has a spike in variance compared to uneventful days.

17.1. Principal component analysis

The principal component analysis is in essence a dimension reduction tool. In the case of our model, we use regression analysis of several Treasury bond rates and CIBOR rates with different maturities as explanatory variables in order to test whether they influence Danish equity prices. It is fair to assume that Treasury bonds and Interbank lending rates, despite having different maturities, will in fact be heavily correlated within themselves. There are of

course exceptions to this; there can be a change in the short-term interest rate, yet long-term outlook hasn't changed and the long-term rate therefore remains. Yet on aggregate, a shift in the yield curve of Treasury bonds will affect all maturities, which will create a large portion of correlation. The correlations of the Treasury bond and CIBOR rates of different maturities of our dataset are shown in Table 4 and 5.

Table 4 Correlations of CIBOR rates with different maturities.

Calculated on entire dataset, and using excel.

Correlations	*CIBOR 1 Month*	*CIBOR 2 Months*	*CIBOR 3 Months*	*CIBOR 6 Months*	*CIBOR 9 Months*	*CIBOR 12 Months*
CIBOR 1 Month	1					
CIBOR 2 Months	0,910279	1				
CIBOR 3 Months	0,875969	0,981448	1			
CIBOR 6 Months	0,845692	0,954252	0,972312	1		
CIBOR 9 Months	0,815676	0,924724	0,945127	0,983522	1	
CIBOR 12 Months	0,779775	0,888054	0,911093	0,962266	0,986536	1

Table 5 Correlations of the Danish Treasury bond rates with different maturities.

Calculated on entire dataset, and using excel. TB stands for Treasury bond, 1 the number for the years to maturity.

Correlations	*TB 1Y*	*TB 2Y*	*TB 5Y*	*TB 10Y*	*TB 30Y*
TB 1Y	1				
TB 2Y	0,507048	1			
TB 5Y	0,292795	0,799397	1		
TB 10Y	0,317141	0,690951	0,872267	1	
30Y	0,250251	0,520387	0,695394	0,841459	1

The correlations in the CIBOR rates in Table 4 are very high, and albeit the Treasury bond rates in Table 5 are much less correlated, the 5- and 10-year still reach a correlation of 0,87. The problem with these high correlations when trying to prove relationships using multiple regressions is the assumption of no multicollinearity between explanatory variables, also called no perfect correlation. This multicollinearity causes problems for regression models such as ordinary least squares, which is used in this paper. It causes potentially high error terms and the inability to correctly estimate the "most likely" parameters (Stock & Watson 2012). In order to cope with multicollinearity, we use the principal component analysis to reduce the number of explanatory variables. The principal component analysis creates a set of eigenvectors depending on the number of variables/vectors introduced. These eigenvectors are the eigenvectors of the co-variance matrix between the *n* variables with the largest Eigenvalue. They create a linear relationship that maximizes the variation in the dataset, such that the least amount of information is lost. The second eigenvector in principal component analysis is constrained to being orthogonal to the previous eigenvector to capture the remaining variation, given the constraints of the previous eigenvector. The result is a set of eigenvectors with different explanation degrees. When using the principal component, in this paper mainly referred to as PRIN, it is the sum product of the eigenvector and the corresponding maturities, in our case at time t. This creates one variable with the same amount of observations as the individual variables used to create it, a sort of weighted "average", except the weights do not necessarily sum to 1 (Jollife 2002). In our assignment, we will mainly be using just one eigenvector, as the degree to which this one eigenvector explains the variation between the bonds of different maturities, is 70% and upwards. In short, a six-dimension regression with the six different maturities in the CIBOR rate models would be reduced to a one-dimension model, when using just one principal component. This would eliminate the problems with multicollinearity. An example is given below in equation:

(4)

$$PrincipalcomponentObservation1 =$$

$$\Delta CIBOR_{25/01/2015}(-0{,}0125 \quad -0{,}005 \quad -0{,}005 \quad -0{,}0075 \quad -0{,}0025 \quad -0{,}01) \cdot Prin1 \begin{pmatrix} 0{,}38136 \\ 0{,}41381 \\ 0{,}41601 \\ 0{,}41849 \\ 0{,}41397 \\ 0{,}40465 \end{pmatrix}$$

So the value for maximum variation change on this day would be:

(5)

$$\Delta CIBORxPrin1 = -0{,}0125 * 0{,}38136 \pm 0{,}005 * 0{,}41381 \pm 0{,}005 * 0{,}41601 \pm 0{,}0075 * 0{,}41849 \pm 0{,}0025 *$$

$$0{,}41397 + -0{,}01 * 0{,}40465 = -0{,}015289$$

Because this principal component doesn't have a unit, as the weights don't sum to one, it needs to be standardized to make the impact interpretable. Standardization is done through division with the standard deviation of the principal components of all event days.

We compare the values of the standardized Principal Component for each individual event day through regression analysis to the dependent variables; the stock indexes. We do realize that some of the information will be lost using only one principal component. However, we believe the loss of information to be negligible due to the previously mentioned high explanation degrees of the primary eigenvectors. In the result part, however, we will be creating two separate principal components for long and short-term Treasury bond rates as part of our investigation, due to a secondary eigenvector that showed oppositely correlated effects between the short and long-term.

17.2. Events

As previously explained, our model is built on multiple regression analysis and principal component analysis. In order to correctly induce causality, we treat the speeches as exogenous variables and use the information given on any day to measure first the influence this event has on the two different types of interest rates, and later the subsequent effect on the equity prices in Denmark. The speeches thus serve as a measure of monetary policy shock, and the effect it has on market interest rates are assumed to be causal. We base this on the large amount of literature documenting this causal relationship. As mentioned in Part V, Fratzscher et al. (2014); Bernanke & Kuttner (2005); Wright (2012) and Drejer et al. (2011), all find that monetary policy affect asset prices. Although Bernanke & Kuttner (2005) find that only unanticipated monetary policy shocks have an effect, we assume on the basis of their research that a causal relationship exists. In this model, a monetary policy shock is therefore

measured in its effect on the Treasury bond and CIBOR rates. We assume that these two represent the market rates, while still testing for what in Drejer et al. (2011) refer to as the interest rate channel, explained in the channels chapter. We find that the interest rates offered by the Danmarks Nationalbank represented by the CIBOR rates, affect the market rate as an alternative rate for large bank institutions.

We use this causality to further investigate how these shocks in interest rates, based on information from various sources, affect the equity market in Denmark. Because of the exogeneity of the events and the efficient market hypothesis, we believe that the effects measured in the C20 index on the day of event can be assumed to be a response to the information about monetary policy. The events, therefore, serve as a representation of where the information is coming from. The most notable difference, as will be shown, is between the information released by the US Federal Reserve and the information released by the ECB. We try to find a model with specific events that we think are relevant to the stock market, and add information to the monetary market. But our main model remains as the entire amount of information provided by the ECB and Danmarks Nationalbank. This produces what we believe to be a sufficient amount of observations. We acknowledge that perhaps a portion of the events may not necessarily be entirely relevant, but assume that the aggregate result will still be useful.

We believe that besides the causality, as mentioned in the descriptive part, the Danish monetary policy is built up and maintained on the idea that stability is key. If stability is key, and the fact that Denmark has always been dedicated and forward about their dedication to maintain the peg, it must make any potential monetary change all the more important.

PART VII - Results

18. Results

In this chapter we will state the results and provide some comments. We made several different models with different abilities of capturing the relationship between the Danish equity prices measured by different sectors and sizes, and different monetary policies, interest rates, different central banks, and the importance of events.

We developed two main models to identify relationships between monetary policy and the Danish stock market. One that utilizes changes in CIBOR interest rates on event days, and another that uses the changes in Danish Treasury bond rates/yields (TB rates) on event days. They both include all events, meaning every piece of information that has come out of NB and the most significant announcements and actions coming from ECB through the period.

In addition to this we have created restricted models where we have limited the number of events through qualitative analysis highlighted in the events chapter. The restricted models include:

- *Interest changes*, which includes only the days at which the NB cut or increased their interest rates.
- *NB Unconventional*. This model supplement the *All Events* model with a dummy variable that will capture the unconventional actions taken by Danmarks Nationalbank
- *ECB announcements* that includes only information given by ECB regarding its unconventional monetary policies.
- *FED announcements*, which includes only information from the Federal Reserve regarding its unconventional monetary policy announcements. This information is not included in any of the other models. The model using FED announcements have been lagged 2-days to allow for any lag between the time of the publishing to the time investors receive the information to be accounted for.

18.1. Danish Treasury bond:

In an earlier chapter we have discussed the potential existence of multicolinearity. To avoid this, instead of comparing the changes in individual maturities of the Treasury bond rates, we create a variable using loadings from eigenvectors created using principal component

analysis. Before proceeding to the regression results we go through the results from the principal component analysis.

Table 6 Degrees of variation explained in the entire model by the eigenvectors.

The table below presents the variation explanation percentages that each individual eigenvector up to the 3rd in order of variation explained. It is made using the changes in Treasury bond rates on event days in our full model. The remaining eigenvectors explaining jointly about 1% of the variation has been left out.

Eigenvectors:	Percentages of variation Explained
Prin 1	75%
Prin 2	19%
Prin 3	4%

As can be seen in table 6, the first two eigenvectors collectively explain 94% of the variation between the maturities in the changes in the yield of Treasury bonds with maturities ranging from one to thirty years. Of the 94%, 75% is explained by the first eigenvector. There was a total of 5 eigenvectors, corresponding to the amount of maturities that where included in the analysis. We begin our analysis assuming this is a sufficient explanation degree to capture the effects from changes in the Treasury bond rates.

Table 7. First and second eigenvector from Principal component analysis.

The table below presents the first and the second eigenvector loadings from a principal component analysis done in SAS Enterprise Guide. It is made using the changes in Treasury bond rates on event days in our full model. Eigenvectors above 2 in order of relevance have not been included, since the join explanation degree of the remaining only accounts for 6%.

Eigenvectors:	PRIN1	*PRIN2*
1Y	**0,370786**	0,658268
2Y	**0,460572**	0,387049
5Y	**0,492461**	*-0,044379*
10Y	**0,475558**	*-0,368674*
30Y	**0,426284**	*-0,528191*

In table 7, only the first two eigenvectors are listed. Due of the high explanation degree, we avoided including more principal components. The reason we included the second Eigenvector, even with 75% variation explained by the first, is because the second one has negative loadings on long-term Treasury bond rates, hinting that there could be an opposite

relationship between long-term and shot term Treasury bonds. This will prove to be useful later in the paper.

18.2. Results from changes in Treasury bond rates on the stock market.

Table 8. The response of OMX Copenhagen C20 to changes in the Danish Treasury bonds unseparated.

The table below presents the results from the regression between, the standardized principle component of daily changes in the Danish Treasury bonds with maturities 1, 2, 5, 10 and 30 years, and the daily changes in the C20. The regression is full sample, there has been no outlier reduction in the observations, besides the initial years of the great recession where we were unable to obtain sufficient data. The number of observations is 88. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level.

	Full Sample
Intercept	0,00072
	(0,61)
Treasury bond changes	0,00331**
	(2,35)
$\overline{R}^2$	0,07

It is slightly surprising to note that an increase in interest rates would accommodate an increase in the equity prices. According to Bernanke & Kuttner (2005), there is a reversed causal and statistical effect between the interest rates and the stock market. They find that an unanticipated increase in the federal funds rate of 25 basis points corresponds to a 1% drop in stock prices. In the above regression, a one standard deviation increase in the Treasury bond rates of different maturities, increase the stock market by 0,3%. This finding is significant at the 5% level.

This could be due to several factors. Since this analysis is done on the basis of Treasury bond interest rates and is a mix of relatively different maturities, there could be opposing effects from the long-term interest rates and the short-term interest rates. In the principal component analysis, the second eigenvector showed negative weights on the longer-term maturities. In order to test for this relationship, we initiate a test using Treasury bond rates separated into long- and short-term maturities. The loadings are created using two principal component analyses: one principal component analysis for long-term rates, and one for short-term rates. The reason we use two principal component analysis' individually on long-term

and short-term rates, and not just simply use the second eigenvector in the previous principal component analysis, is due to the orthogonality properties of a principal component analysis. This would render a potential regression analysis useless, since the second eigenvector would point the opposite direction in a 3D diagram, and ordinary least squares regression analysis would be incapable of creating estimates with these constraints.

In order to shed light on the C20 market index's potential bias we also include a regression using OMX Copenhagen Mid Cap, an SMB index and a model where large outliers have been removed as dependent variables.

18.3. Comparison with Midcap and SMB

Table 9. The response of OMX Copenhagen C20, Midcap and SMB to changes in the Danish Treasury bond separated on maturity.

The table below presents the results from the regressions between, the standardized principle component of daily changes in the Danish Treasury bond with maturities 1, 2 years as short-term rates and 5, 10 and 30 years as long-term rates, and the daily changes in the C20, Midcap and SMB. Column a uses daily changes in C20 as the dependent variable. The regression is full sample, there has been no outlier reduction in the observations, besides the initial years of the great recession where we were unable to obtain sufficient data. Column a has 88 observations. Column b uses daily changes in Midcap as the dependent variable and column c uses daily changes in SMB as the dependent variable. SMB is calculated as C20 less the OMX Smallcap index. Both column a and b are full sample, there has been no outlier reduction in the observations. However, due to further constraints on data availability the regressions in column b and c only have 78 observations. Column d shows the same regression as column a, but has been reduced on the basis of extreme events. By extreme events refers to any event that has created a shock in Treasury bond rates of more than 1,5 standard deviations in either direction. This leaves column d with 79 observations. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level.$\bar{R}^2$is the adjusted r squared.

		Full Sample		**No Outliers**
	a	b	c	d
	C20	Midcap	SMB	C20
Intercept	0,0005	0,0015*	0,0008	0,0002
	(0,48)	(1,95)	(-0,76)	(0,24)
Treasury bond changes Long-term	0,0053***	0,0042***	-0,0039***	0,0048**
	(3,20)	(4,94)	(-2,81)	(2,37)
Treasury bond changes Short-term	-0,0021	-0,0023***	0,0030**	-0,0026
	(-1,32)	(-3,02)	(2,06)	(-1,55)
$\bar{R}^2$	0,11	0,19	0,08	0,07

Interestingly, we find an opposite relationship between long-term and short-term interest rates, using both the Midcap- and C20 index. The results on long-term in column *a* and *b* are

not significantly different from each other on the 5% level.[28] When long-term Treasury bond rates increase by one standard deviation, the C20 increase by 0,5% and vice versa. The C20 drops, on the other hand, by 0,2% if short-term Treasury bond rates increase by one standard deviation. The coefficient on short-term Treasury bond rates is not significant in column *a* using the C20. However, it is significant in column *b*. This could potentially mean that smaller businesses are affected by changes in the short-term yield whereas larger are not. We will discuss this further in the interpretation part of the assignment.

Comparing the regression in Table 8 and Table 9, we get an even more positive estimate on the long-term Treasury bond rates. This is a bit contradicting to prevailing prior research, and will be investigated in greater detail in the results.

The regression in column *c* shows two significant estimates. Both the estimates for long and short-term Treasury bond rates are statistically significant on the 5%-level. The estimates show that an increase in short-term Treasury bond rates of one standard deviation will increase the spread between the yield of small and large companies by 0,3%-points. At the same time, an increase in long-term TB rates of one standard deviation will decrease the spread between the yield of almost 0,4%-points.

The no-outlier regression in column *d* shows that excluding the outliers doesn't change the results. They are still significant, point in the same direction, and provide very similar estimates.

18.4. Including recession dummy

Due to the previous discovery of a large positive relationship between the changes in long-term Treasury bond rates and the C20, a finding that runs contrary to conventional wisdom in general and the finding of Bernanke & Kuttner (2005) in particular, warrants a further investigation. A possible explanation to this could be the existence of a signaling channel as mentioned in Krishnamurthy & Vissing-Jørgensen (2011). A possible way to identify the existence of a signaling effect would be to include a recession dummy. There ought to be a difference in how the signaling effect affects the stock markets in and out of recessions. We therefore created such a dummy variable and entered it into all of the four previous

[28] We calculated this using Welch's t-test

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}}$$

regressions. The recession dummy was not multiplied with the short-term rate because the short-term rates already have the expected effect, the short-term rate is generally not part of the balance channel since companies use long-term rates to discount future cash flows and because, as Krishnamurthy and Vissing-Jørgensen (2011) argues that the signaling effect mainly affect long-term bond rates. Moreover, Eggertsson and Woodford (2003) state that *"[...]non-traditional monetary policy can have a beneficial effect in lowering long-term bond yields only if such policy serves as a credible commitment by the central bank to keep interest rates low even after the economy recovers.",* meaning that the signaling effect is only observable if it serves as a long-term commitment.

Table 10. The response of OMX Copenhagen C20, Midcap and SMB to changes in the Danish Treasury bond separated by maturity. Including recession dummy.

The table below presents the results from the regressions between, the standardized principle component of daily changes in the Danish Treasury bonds with maturities 1, 2 years as short-term rates and 5, 10 and 30 years as long-term rates, and the daily changes in the C20, Midcap and SMB. The amount of observations are equivalent to the results in table 4. The recession dummy is a cross-variable between a recession dummy and the daily changes in Treasury bond long-term rates. The recession dummy is a variable that includes a 1 if the daily change belongs in a month that comes after 2 consecutive quarters with negative real growth. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level.$\bar{R}^2$is the adjusted r squared.

	Full Sample			**No Outliers**
	a	b	c	d
	C20	Midcap	SMB	C20
Intercept	-0.0002	0,0014*	-0,0006	-0,0003
	(-0,15)	(1,84)	(-0,62)	(0,24)
Treasury bond changes Long-term	0,0080***	0,0056***	-0,0047**	0,0115***
	(4,61)	(4,41)	(-2,27)	(3,03)
Treasury bond changesShort-term	-0.0014	-0,0018**	0,0028*	-0,0029**
	(-1,00)	(-1,93)	(1,93)	(-2,00)
Recession dummy Long-term	-0.0064**	-0,0025*	0,0015	-0,01067**
	(-2,78)	(-1,53)	(0,60)	(-2,61)
$\bar{R}^2$	0,18	0,21	0,08	0,18

The regressions above reveal an interesting result; looking at column *a*, we observe a large negative estimate for the cross-variable between long-term Treasury bonds while being out of recession. This ultimately means that while not in recession, the positive effect of a one standard deviation increase in long-term Treasury bonds is reduced from 0,0080 or 0,8% to 0,15% (0,0080-0,064). However, it does remain positive. It makes sense that while in

recession, the market looks for any positive news as a signal of better times, but even when not in recession this signal effect remains larger than the balance effect, which is pulling it in the opposite direction. There must be something specific going on in the Danish economy, potentially powered by the euro-peg, which leads to this unexpected effect. From column *b* and *d,* we observe the same fundamental result, albeit in different magnitudes. In neither of the regressions the recession estimate is in absolute values larger than the estimate on long-term Treasury bond rates. In column *c* we included a small minus big term that represents the spread between rate of return on large and small companies on event days. It shows the same effect as in table 9 and, not surprisingly, the recession dummy doesn't significantly affect this. Nevertheless, the fundamental results remain: when long-term Treasury bonds increase, the spread decreases and vice versa for short-term Treasury bonds.

Throughout the remainder of this result chapter we will continue to try to find out what mechanism leads to this effect.

In table 9 we found similar results among all the different dependent variables, hinting that the C20 is a sufficiently representative market index. However, to be certain we further look at the relationship between the pharmaceutical industry and Treasury bond rates. This will also render more information regarding the effects of monetary policy in Denmark on differently sized entities. Furthermore, it will help us identify in which way the Treasury bonds and the money market affects the stock market.

18.5. Comparison with Pharmaceutical industry

In this chapter we compare the TB rate changes with our index for the pharmaceutical industry. The indexes are separated into sizes, large and big represented by Pharmaceutical and Biotech companies, respectively. Novo Nordisk is part of the pharmaceutical industry's index, but not the biotech. The biotech index therefore does not explain whether C20 is a good estimate for the market index, but in fact exist to shed light on the hypothesis of the existence of a signaling effect and risk-taking channel.

Table 11: The response of Pharmaceutical Index and Biotech Index on changes in the Danish Treasury bond separated on maturity. Both including and excluding recession dummies.

The table below presents the results from the regressions between, the standardized principle component of daily changes in the Danish Treasury bond with maturities 1, 2 years as short-term rates and 5, 10 and 30 years as long-term rates, and the daily changes in a pharmaceutical index and a biotech index. The amount of observations are equivalent to the results in table 1. The recession dummy is a cross-variable between a recession dummy and the daily changes in Treasury bond long-term rates. The recession dummy is a variable that includes a 1 if the daily change belongs in a month that comes after 2 consecutive quarters with negative real growth. The construction of the indexes have been explained in an earlier chapter. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level.$\bar{R}^2$is the adjusted r squared.

	Without recession dummy		**With recession dummy**	
	a	b	c	d
	Pharmaceutical index	Biotechnological index	Pharmaceutical index	Biotechnological index
Intercept	0.0008	0,0002	0,0007	-0,0006
	(0,68)	(0,11)	(0,64)	(0,24)
Treasury bond changes Long-term	0,0015	0,0040	0,0017	0,0072*
	(0,85)	(1,36)	(0,61)	(1,82)
Treasury bond changes Short-term	0.0007	-0,0013	0,0007	-0,0007
	(0,45)	(-0,53)	(0,48)	(-0,29)
Recession dummy Long-term			-0,0003	-0,0075*
			(-0,10)	(-1,75)
$\bar{R}^2$	0,00	0,01	0,00	0,03

Not any of the estimates in the regressions in column *a* and *b* are significant, not even on the 10% level. When including a recession dummy term, two of the estimates in the regression using the biotech index become significant on the 10% level. The long-term Treasury bond rates and the recession dummy are significant in column *d*. They are not significant even when including the recession dummy in column *c* on the pharmaceutical index. This shows that there exists a difference in the way changes in the Treasury bond on event days affect larger and smaller companies. However, it provides more proof that using C20 as market maker index is not influenced heavily by Novo Nordisk predominant position in said index.

An interesting finding in the regression in table 11, is that the cross variable between the dummy for not being in recession and the long-term Treasury bond rates is negative and larger in magnitude than when in recession as seen in column *d*. This means that when in

recession, a one standard deviation increase in Treasury bond rates increases the value of biotech companies by 0,7%. On the contrary, in times of an growing economy, an increase in the Treasury bond rates of one standard deviation decreases the value of biotech companies by 0,01% (0,72%-0,73%).

The regression with the Treasury bond rate changes and the index for pharmaceutical companies in column *a* and *c* yielded very insignificant results. None of the variables were significant, not even on a 10%-level. Another notable thing is the very small estimates in column *a* and *c* compared to column *b* and *d*. Even if they had been significant, their effect on the price of large pharmaceutical companies had been negligible. Since the long-term Treasury bond is insignificant when looking specifically at the large pharmaceutical industry in column *a* and *c*, the effect when using C20 as a representation of the market might bias towards insignificance.

18.6. Comparison with banking index

In this part we will test the existence of an interest rate channel, as discussed in an earlier chapter. In this test, we compare the changes in Treasury bond rates towards two indexes including respectively large and small bank shares. The theory is that there will be a significantly lower effect from the events on the smaller banks compared to the larger banks since larger banks have access to Danmarks Nationalbank loans and deposits.

Table 12. The response of Large and Small bank indexes on changes in the Danish Treasury bond separated on maturity, including and excluding recession dummies.

The table below presents the results from the regressions between, the standardized principle component of daily changes in the Danish Treasury bond with maturities 1, 2 years as short-term rates and 5, 10 and 30 years as long-term rates, and the daily changes in an index of large banks and an index of small banks. The amount of observations are equivalent to the results in table 1. The recession dummy is a cross-variable between a recession dummy and the daily changes in Treasury bond on long-term rates. The recession dummy is a variable that includes a 1 if the daily change belongs in a month that comes after 2 consecutive quarters with negative real growth. The construction of the indexes have been explained in an earlier chapter. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level.$\bar{R}^2$is the adjusted r squared.

	Without recession dummy		**With recession dummy**	
	a	b	C	d
	Small bank index	Large bank index index	Small bank index	Large bank index index
Intercept	0.0008	0,0023	0,0003	-0,0012
	(0,72)	(1,2)	(0,28)	(0,70)
Treasury bond changes Long-term	0,00421**	0,0095***	0,0062***	0,0136***
	(2,88)	(4,78)	(3,33)	(4,75)
Treasury bond changes	-0.0027*	-0,0035*	-0,0023	-0,0027
Short-term	(-1,64)	(-1,56)	(-1,38)	(-1,35)
Recession dummy			-0,0047*	-0,0095**
Long-term			(-1,62)	(-2,31)
$\bar{R}^2$	0,07	0,14	0,10	0,19

The regression in column *a* and *b* in table 12 show that there is a significant difference between the estimates of the effects from changes in the long-term Treasury bond depending on the size of the bank. Both estimates on small and large banks are significant on the 5% level, and the estimate on small banks is less than half that of the large banks. An increase by one standard deviation effects large banks by 2,25 times as much as the small banks (0,0095/0,00421). This stays roughly the same when introducing the significant recession dummy in column *c* and *d*. Another notable discovery is the magnitude that large banks are affected by an increase in the long-term Treasury bond. An increase in long-term Treasury bond rates effect large banks 1,7 times as much as the equivalent effect on the C20. This is probably due to the fact that a significant proportion of bank's profits represent interest income, and when the market requires larger interest rates, the banks' earnings increase.

The short-term Treasury bond rate estimates are significant in the column *a* and *b*, but become insignificant in column *c* and *d* when the recession dummy is introduced. The results

show that even out of recession there is still a significant and positive relationship between long-term Treasury bond rate increases and the stock prices of banks of either size. This is in accordance with the existence of an interest rate channel. We did not expect the small banks to be so influenced by the interest rates since they cannot use the Danmarks Nationalbank deposits as alternative interest rates like larger bank institutions.

18.7. Results from CIBOR rates:

As explained in earlier chapters, the CIBOR interbank lending rate is a short-term interest rate that a bank is willing to charge another bank. In a similar fashion, we did a principle component analysis, due to the potential multicolinearity, to determine the principal vector that explains the variation in the dataset.

Table 13. Degrees of variation explained in the entire model by the eigenvectors.

The table below presents the variation explanation percentages that each individual eigenvector up to the 3rd in order of variation explained. It is made using the changes in CIBOR rates on event days in our full model. The remaining eigenvectors explaining jointly about 0,3% of the variation and has been left out.

Eigenvectors:	Percentages of variation Explained
Prin 1	99%
Prin 2	0,6%
Prin 3	0,1%

Table 14. First and second eigenvector from Principal component analysis.

The table below presents the first eigenvector loadings from a principal component analysis done in SAS Enterprise Guide. It is made using the changes in CIBOR rates on event days in our full model. Eigenvectors above the principal one in order of relevance have not been included, since the join explanation degree of the remaining only accounts for 1%.

Eigenvectors:	PRIN1
CIBOR, 1 month maturity	**0,408042**
CIBOR, 2 months maturity	**0,409159**
CIBOR, 3 months maturity	**0,407795**
CIBOR, 6 months maturity	**0,409587**
CIBOR, 9 months maturity	**0,408641**

There is a strong correlation between the variables, which is visible in the results. All of the weights are very similar in size, and the remaining eigenvectors explain an abysmal amount of the variation between the maturities.

Below is the first regression including all event days, CIBOR and C20.

Table 15. The response of the C20 and Midcap on changes in the CIBOR rates with all maturities including recession dummies.

The table below presents the results from the regressions between, the standardized principle component of daily changes in the CIBOR interbank rates, and the daily changes in the C20 and Midcap market indexes. There are more observations than in previous regressions due to easier access to data. The number of observations is 119 in the regression in column a. The number of observations is 68 in column b due to data scarcity. In column d all observations where the absolute value of the principal component is above 1,5 standard deviations have been removed. The number of observations in column d is 102. The recession dummy is a cross-variable between a recession dummy and the daily changes in CIBOR rates. Column d is created like c, but uses our index for large banks rather than C20. It has only 97 observations, because of unavailability of large bank share prices prior to mid 2006. The recession dummy is a variable that includes a 1 if the daily change belongs in a month that comes after 2 consecutive quarters with negative real growth. The construction of the indexes have been explained in an earlier chapter. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level .$\overline{R}^2$is the adjusted r squared.

	Full Sample		**No Outliers**	
	a C20	b Midcap	c C20	d Large Banks index
Intercept	0.0003 (-0,15)	0,0021** (2,36)	0,0015 (0,98)	0,0035 (1,40)
CIBOR rates all maturities	-0,0037 (-1,28)	-0,0069 (-0,44)	-0,0002 (-0,04)	-0,0045 (-0,50)
Recession dummy	-0.0003 (0,06)	0,0067 (0,42)	-0,006 (0,08)	-0,0021 (-0,19)
$\overline{R}^2$	0,03	-0,03	-0,02	-0,01

In table 8, it is shown three regressions, all using the CIBOR interbank rate changes instead of the Treasury bond rates. Many of the regressions using the Treasury bond short-term rates proved insignificant, and due to the short-term property of the CIBOR rates, the findings are not surprising. Neither of the regressions in column *a, c* or *d* have relevant estimates. Only column *b*, whose estimate for intercept is significant on the 5 percent level. This, however, is a not a useful result, and could be due to the data scarcity and limited observations. Yet, the results do emphasize one important point in that the short-term rates are not what affect the stock market. They do not affect the balance channel, nor functions as a signal to the Treasury bond. In column *d* we compared the CIBOR rate principal component to the large bank index,

which was the most significant of the banking indexes in the Treasury bond part that had the strongest relationship with Treasury bond rates. Not even this was significant on the 10 percent level, indicating that there is not much information to be found using the short-term rates.

18.8. Treasury bond models with less events

In this section we will be looking at some models that include a different set of events. In an earlier chapter we came up with a set of events we believe to be useful to explain movements in the interest rates. In the previous models, we have been using full sample models, meaning we have not excluded any events, unless it has been required by the outlier requirements.

Table 16. The response of C20 to changes in the Danish Treasury bond separated on maturity.

The table below presents the results from the regressions between, the standardized principle component of daily changes in the Danish Treasury bond with maturities 1 and 2 years as short-term rates and 5, 10 and 30 years as long-term rates, and the daily changes in the C20. The amount of observations vary with each regression since the amount of event days vary significantly.. The regression in column a includes 12 observations. The regression in column b includes 15 observations. The regression in column c includes 21 observations. The events have been selected on the basis of their origins. The regression with FED announcements in column b has been created using a 2-day window on both interest changes and changes to the C20, because of the time difference between the US and Denmark. The recession dummy is a cross-variable between a recession dummy and the daily changes in Treasury bond long-term rates. The recession dummy is a variable that includes a 1 if the daily change belongs in a month that comes after 2 consecutive quarters with negative real growth. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level. $\overline{R}^2$is the adjusted r squared.

	Nationalbank's rate changes only	**FED announce-ments only**	**ECB announce-ments only**	**NB Unconvention al**
	a	b	C	D
	C20	C20	C20	C20
Intercept	-0,0006	-0,0057	0,0029	-0,0018
	(-0,20)	(-1,77)	(0,62)	(-1,11)
Treasury bond changes Long-term	0,0165***	-0,0150***	0,0068	0,0058***
	(3,80)	(-3,44)	(1,25)	(2,70)
Treasury bond changes Short-term	0,0042	0,0046	-0,0063*	
	(1,39)	(1,53)	(-1,98)	
Recession dummy Long-term	-0,0241***	0,0046	0,0083	
	(-5,08)	(1,17)	(0,89)	
NB Unconventional dummy				-0,0091**
				(-2,02)
$\overline{R}^2$	0,63	0,30	0,15	0,09

In table 16, several regressions are listed that represent a different set of event days. In the first regression in column *a*, only announcements and interest rate changes in Danmarks Nationalbank's monetary policy interest rates are including. It shows a large and significant estimate on the long-term Treasury bond rate, even at the 1 percent level. It also has a significant and, in absolute value, larger estimate on the recession dummy, implying that the responses from a change in the Treasury bond rates on behalf of a rate cut/hike from Danmarks Nationalbank has a large effect on the stock market. In the previous models using all events and C20 as the market marker, even when outside of recession, the estimate on long-term Treasury bond rates was positive. In this model, however, it turns negative with a value of -0,76% (0,0165-0,0241).

A very interesting finding is the estimate in column *b*, since this regression, using only information stemming from the US Federal Reserve where monetary policy announcements, has a large negative estimate on long-term Treasury bond rates, unlike most of the previous models. This result corresponds precisely to what Bernanke & Kuttner (2005) and Wright (2012) claims, a relatively large increase in stock prices following a relatively loose monetary policy announcement. For comparison, the results shown in column *c* are not significant, only the short-term TB rates, which is not all that relevant for our research, given their insignificance in previous models. The events that are used in this model, are the announcements coming from ECB regarding its monetary policy. Given the Danish euro-peg and the efficient market hypothesis, we expected a different result using these events. The fact that there is a difference between how the Danish equity prices react to news from Europe and the US, lead us to believe that something is going on within the EU and Eurozone, and that this might help us explain the positive relationship between Treasury bond rates and the Danish stock prices.

Earlier in the assignment, in Part III, we described the unconventional monetary policies conducted by Danmarks Nationalbank. We argued that these were the introduction of zero- and negative monetary policy interest rates, the further decrease of already negative interest rates, and the establishment of two long-term credit facilities. These events summed up to 9 in total, which were assigned to a dummy variable in order to determine which of the inflationary or deflationary forces is the dominating one. As can be observed from table 16, we see that these events introduce a negative relationship between long-term yields and the

C20 index, significant at the 5% level. Like the finding above, this finding also support a majority of the relatively new research regarding the unconventional monetary policies and their effect on equity prices conducted since the outbreak of the financial crisis. Nevertheless, it should be noted that only 9 events are defined as unconventional, and that 5 of these events occurred between September 2014 and February 2015, with 4 in 2015. Given this small and concentrated sample, we are cautious in reading too much into this result, other than that it supports the majority of research conducted on unconventional monetary policy in recent years.

18.8. The Treasury bond analysis separated in periods

In the previous results we found that, contrary to Bernanke & Kuttner (2005), an increase in stock prices when Treasury bond rates increased due to a monetary policy event believed to be of the loose/easy kind. We tried to specify where these changes originated and found that the ECB announcements had limited effect on the Danish stock market, but that news coming from the Danmarks Nationalbank and Federal Reserve had significant effects, albeit in opposite directions. The results using news stemming from the Federal Reserve showed a negative relationship between the interest rates and stock prices. This leads us to believe that there are certain effects within the Danish fixed exchange-rate regime that creates this positive relationship between interest rates and stock prices. We also found that the recession dummy was large and significant. In order to further validate that there is a difference between how stocks are affected by monetary policy over time, we make a regression analysis comparing the different time periods through a qualitative selection.

The periods in question are:

1. *End of 2006 until mid 2009*. This was largely the duration of the great recession. Certain economists also refer to this period as the liquidity crisis. In combination with a large under-supply of liquidity, the massive capital flight from region to region within the EU renders it hard to distinguish causality between effects during this period of time.
2. *From mid 2009 to 2013*, which was when the European debt crisis took and peaked. In this period, the southern parts of Europe experienced massive interest rates increases and poor growth, if any.

3. *From 2014-2015*. This is the period where growth started to appear in the European economies and the debt crisis seemed to subdue. However, this was also the point in time when the Swiss national bank decided to set the Swiss Franc loose from its euro-peg and investors worldwide started to speculate in a potential Danish exit from the ERM II framework.

We were unable to get sufficient data on Danish Treasury bond rates with 1- and 30-year maturity from before 2009. We were therefore unable to separate the Treasury bonds into short- and long-term rates. Instead, we had to run a new principal component analysis using a combination of Treasury bond rates with 2-, 5- and 10 year maturities. We use the inputs from the *All Events* model.

Table 17 Degrees of variation explained in the entire model by the eigenvectors.

The table below presents the variation explanation percentages that each individual eigenvector up to the 3rd in order of variation explained. It is made using the changes in Treasury bond rates on event days in our full model. The remaining eigenvectors explaining jointly about 1% of the variation has been left out.

Eigenvectors:	**Percentages of variation explained**
Prin 1	76%
Prin 2	15%
Prin 3	9%

Table 18. First and second eigenvector from Principal component analysis.

The table below presents the first and the second eigenvector loadings from a principal component analysis done in SAS Enterprise Guide. It is made using the changes in Treasury bond rates on event days in our full model. Eigenvectors above 2 in order of relevance have not been included, since the join explanation degree of the remaining only accounts for 6%.

Eigenvectors:	**PRIN1**	***PRIN2***
2Y	0.549119	*0.833494*
5Y	0.593837	*-.337523*
10Y	0.588070	*-.437454*

In table 17, the percentages of explanation between the three maturities are listed separated upon three potential eigenvectors. In the second eigenvector in table 18, it's visible that there still are opposite effects between the 2 year and the 5- to 10 year maturities. However, due to

insignificance of the short-term estimates on several of the previous models, and due to the high explanation degree of the first eigenvector accounting for 76% of the variation between the three maturities. we will be using only one joint principal component in this part of the results.

Table 18. The response of C20 to changes in the Danish Treasury bonds separated on time period.

The table below presents the results from the regressions between, the standardized principle component of daily changes in the yield of Danish Treasury bond with maturities of two five and ten years and the daily changes in the C20. The amount of observations vary with each regression since the amount of event days vary significantly. The 1st period regression kin column a has 19 observations. The 2nd period regression in column b has 64 observations. The 3rd period regression in column c has 24 observations. In parentheses are the t-statistics calculated using heteroskedasticity-consistent standard errors. Stars represent significance, where one star represents significance on 10% level, two stars 5% level and three stars significance on 1% level.$\bar{R}^2$is the adjusted r squared.

	1st Period 2009-2006 a C20	**2nd period 2013-2009** B C20	**3rd period 2015-2014** c C20
Intercept	-0.00118 (-0,78)	-0.00079248 (-0,48)	-0,0017 (-1,08)
Treasury bond changes In period	0.00937** (1,97)	0,00395*** (2,96)	-0,0050* (-1,89)
$\bar{R}^2$	0,21	0,13	0,17

In the 1st period in column *a* of table 18, we see a large positive estimate for a Treasury bond change. If the Treasury bond rates went up with one standard deviation, the stock prices went up with almost 1 percent, whereas in the 2nd period, in column *b,* this is reduced to 0,4% per standard deviation. We have mentioned in earlier chapters the effect of a signaling channel, which could cause such a relationship, where investors interpret a rate hike as a proof that things are getting better. This coupled with the lack of liquidity during the recession could potentially be what is driving this effect. Since the 1st period is largely equivalent to the recession, we avoid commenting too much on this for now, but will get back to it in the interpretation chapter later. What is interesting in this set of regression, is the fact that even outside of recession in the 2nd period , where we experienced the peak of the European debt crisis, this estimate remains positive. While in the 3rd period in column *c,* it has swapped to become negative. The last estimate is in accordance with the theories of Bernanke & Kuttner

(2005) and Wright (2012). In this period, a one standard deviation decrease in Treasury bond rates would boost stock prices by half a percentage.

In the 2nd period, there is no evidence that the positive relationship is because of a liquidity crisis or signaling effects. The general economic environment in the northern parts of Europe was on the mend in this period. Therefore, we need to look at what is going on within the European union in order to hypothesize what is happening. The Eurozone has created a possibility for investors to move money around without facing additional exchange rate risk. The fact that countries now have lost their ability to devaluate currencies, have removed certain risks connected to investing in money markets. A German investor takes no exchange rate risk by investing in Spanish government bonds, but only takes on the credit risk involved reflected in yields and prices according to efficient markets hypothesis (Bodie et al 2011). However, this risk does not take into account the risk of unanticipated monetary policy shocks. It is on this condition not unrealistic to think that investors invest in countries according to information from central banks. We believe that potentially some of the effect we are observing comes from the movement of capital within the euro area subsequent to news about monetary policy. In this case, the euro area might include Denmark because of the peg towards the euro.

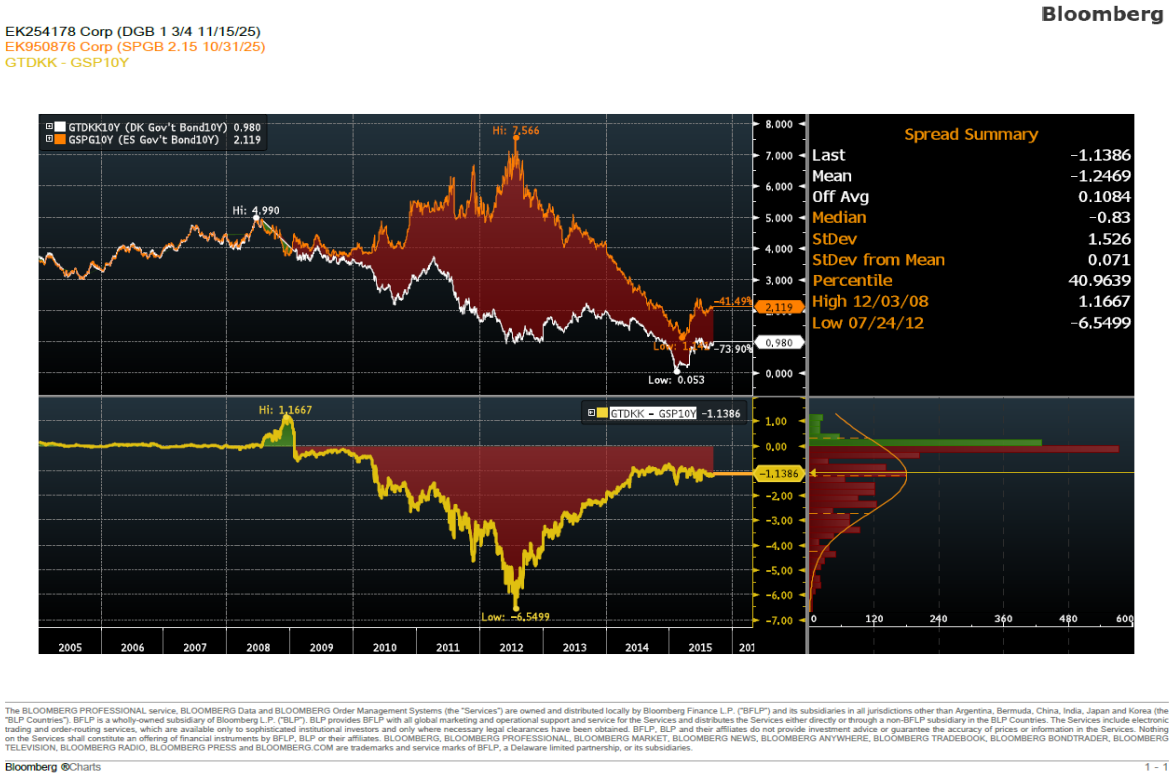
We believe that potentially after the release of unanticipated information, large amounts of money flow from one end of the Eurozone to another. This is in line with the theory of capital flight, defined by Schneider (2003) as outflow of capital due to economic and political uncertainty (Schneider 2003). For instance, when the ECB announces it will purchase European government bonds, or says that it will provide additional liquidity measures aimed at European banks, a large portion of the risk that was involved in buying Spanish, Italian or other distressed governments' bonds within the Eurozone, suddenly disappear, and the interest rates offered on basis of this risk looks increasingly positive. Many investors holding Danish government bonds, then, suddenly move their capital southwards leading to an increase in Danish yield prices, and pushing down the Spanish. This should create a negative correlation between the two alternatives within the euro area and Denmark. So, when important news is released from the ECB, capital flies from one end to the other, reflecting the changed perception of economic- and political risk. In theory, this would mean that some of the news that created large spikes in the government bond yields should have opposite

directions. We take a look at some of these outliers and later set up correlations between the ones with a jump of more than 1,5 standard deviations in the period between 2009-2013.

During this period in addition the spread between the Danish Treasury bond and the Spanish government bond increased and remained very high due to the debt crisis mainly affecting the southern part of the Eurozone.

Figure 18. Spread analysis between the Danish Treasury bond with 10 year maturity, and the equivalent Spanish government bond.

Figure 18 presents a spread analysis between the Danish generic government bond with a 10 year maturity, and the Spanish 10 year generic government bonds. The spread analysis in obtained from Bloomberg (R). The graph in the top represents the nominal rates of the respective government bonds. While the bottom graph presents the Danish government bond less the Spanish.



The figure above shows the spread between the Danish Treasury bond and the Spanish government bond from 2005 to 2015, both with a maturity of 10 years. In fact, looking at the spread between the two government bonds, it is visible that the spread in the period between 2009 and 2012 was dramatically increasing. Although it started decreasing from 2012 to 2013, it remained relatively high until mid 2014. If our theory is correct, that some of the positive relationship between the Danish Treasury bond and the Danish stock market stem from the movement of capital between the southern Europe and Denmark, it would make

sense that during this period of time, since the spread was generally increasing or relatively high, information about the monetary policy would create quite a substantial move in capital. The risk was so high in the south that it warranted a spread in the yield of 6,55 percentage-points on the 24th of July 2012 between the Danish Treasury bond and its Spanish counterpart. Any information relieving the risk in the south would therefore create quite an incentive for investors to move their capital due to the large gain from the spread.

18.8.1 Outliers

In this section, we will present the outliers from our model in order to be able to better interpret the results. The outliers are simply the event days that have the largest impact, which we have defined as having a standard deviation greater than ±1,5. In all, 14 event days met this criterion. On some of the event dates, we suspected that the events from our model, which are announcements and actions solely by NB and ECB, would not be of the magnitude implied by its standard deviation. As such, we went through news related to monetary policy and economic- and political stability in the euro area on the given event days, and went on to replaced those with we think would not capture the magnitude. What we consider to be the most representative events are shown in Table 20.

Table 20. List of outlier events prior to separation between long- and short-term.

Date	PRIN STD	Event(s)
30.01.15	-2,03	NB recommends to stop Issuing Danish Gov. Bonds
19.01.15	-1,59	NB lowers already negative interest rate unilaterally
26.09.12	-1,62	Violent anti-austerity demonstrations across the Eurozone. General Strike in Greece
14.12.11	-1,68	Italian public debt crosses the €2 trillion mark. Fed refrain from taking more stimulus measures.
05.12.11	2,13	European Bailout Fund issues bonds for Spanish banks. Italian debt-reduction proposal presented by the Italian government
12.10.11	1,56	ECB: “Bailout Fund should be backed by Gov. guarantees”. Slovakia finally backs the Fund's expansion

06.10.11	2,02	ECB announces liquidity programs. BoE announces additional QE
03.03.11	3,54	ECB surprisingly expresses a rate hike coming next month, due to inflation
04.06.09	1,69	ECB reveals details of liquidity program. NB lowers interest rates unilaterally
07.05.09	1,61	ECB announces 2 liquidity programs. ECB & NB lower interest rates
02.04.09	3,00	ECB hints at unconventional measures to be introduced next month at press conference. ECB & NB lower interest rates
08.12.08	2,06	Markets surge on stimulus hopes, with major European indices up 6-9%
24.10.08	1,66	NB raises interest rates unilaterally
16.05.08	1,97	NB raises interest rates unilaterally. Bernanke appeals to Congress

A more thorough investigation of these outliers will be given in the Discussion section. Still, it is worth noting that many of these outliers support the notion that capital flows from Denmark to Europe, in particular the southern European countries, when ECB tries, in various ways, to implement stimulative and stability-enhancing measures during the period between mid 2009 and 2013, a period that is associated with the European debt crisis. This movement of capital suits the definition given by Schneider (2003) of capital flight as outflows of "... capital which is motivated by economic and political uncertainty" (Schneider 2003, p. 3).

Starting with the first two events in 2008, where NB raises interest rates, these tend to follow the conventional response to monetary policy. The three events taking place between April and June 2009, in our 2nd period, demonstrate the capital movements mentioned: when ECB hints at, announces or explains its unconventional liquidity program, capital seem to leave Denmark for the benefit of the now relatively safer Eurozone, even when the monetary policy interest rates are unilaterally lowered in Denmark. Still, the event with the largest standard deviation is when ECB surprisingly communicate that a rate hike is coming next month. For instance, one of Denmark's largest banks, Jyske Bank, believed, prior to the press conference, that the ECB would not raise rates until the end of 2011.[29] Due to the euro-peg, markets immediately recognize that the central bank of Denmark has to follow with a rate hike of their

[29] http://jyskebank.tv/012990618301911/10-i-9---fokus-paa-rentemoedet-i-ecb

own. Nevertheless, for the rest of 2011, the events confirm the notion of capital flow, with ECB and the European bailout fund seeking to enhance economic stability in the region. In December 2011, for instance, the public debt of Italy crosses the psychological mark of 2 trillion euro on the same day as the Federal Reserve refrain from providing the market with more measures to stimulate the economy. Moreover, next event that is defined as an outlier is caused by violent anti-austerity demonstrations taking place in the distressed economies in the Eurozone, including Spain and Greece[30]. In addition, a general strike among public- and private workers in Greece happened the same day, with both events contributing to an increase in the perceived political, and hence economic, risk in the region.

The last two events, taking place in January 2015 and in our 3rd period, concern the actions of Danmarks Nationalbank. On January 19th it lowers the already negative certificate of deposit with 15 basis points to -0,20%. In addition, it lowers its lending rate by the same amount to 0,05%. Eleven days later, upon the recommendation of Danmarks Nationalbank, the Ministry of Finance suspended the issuance of domestic and foreign bonds.[31] By limiting supply this way, all else equal, the prices and yields of these government bonds will rise and fall, respectively.

Next, we divided the above analysis, as we did in our model, into a short-term- and a long-term component. By using the same definition of an outlier, the latter is depicted in Table 21.

Table 21. List of outlier events only using principal component on Long-term

Date	Prin Long STD	Event
30.01.15	-1,73	NB recommends to stop Issuing Danish Gov. Bonds
26.09.12	-2,20	Anti-austerity demonstrations across the Eurozone. Mr. Abe wins election
06.09.12	**1,71**	**ECB announces details of the OMT program, which pleases the market**
02.08.12	**-2,06**	**ECB disappoints market at press conference**

[30] http://www.dw.com/en/european-stocks-post-biggest-fall-in-months/a-16266899
[31] http://www.nationalbanken.dk/en/pressroom/Documents/2015/01/DNN201521749.pdf

14.12.11	-2,19	Italian public debt crosses the €2 trillion mark. Fed refrain from taking more stimulus measures
05.12.11	2,61	European Bailout Fund issues bonds for Spanish banks. Italian debt-reduction proposal
12.10.11	2,00	ECB: "Bailout Fund should be backed by Gov. guarantees". Slovakia finally backs the Fund's expansion
06.10.11	1,94	ECB announces liquidity programs. BoE announces additional QE
03.03.11	2,66	ECB surprisingly expresses a rate hike coming next month
07.05.09	2,39	ECB announces 2 liquidity programs. ECB & NB lower interest rates
02.04.09	2,29	ECB hints at unconventional measures to be introduced next month. ECB & NB lower interest rates

As can be seen, many of the same events as in the original analysis yield a standard deviation greater than 1,5. This analysis does include two additional events (marked in bold). On the first of those events, on August 2nd 2012, the ECB disappointed market participants[32]. Mario Draghi was very vague and stated that "maybe" the ECB would go through with the OMT Program. The market had expected more, especially considering that ECB earlier the same day did not lower any interest rate, and due to the fact that the chairman recently stated that he would do "whatever it takes" to save the euro[33]. On ECB's next meeting, however, on the 6th of September, Mr. Draghi put forward details regarding the Outright Monetary Transactions program[34]. This program, Draghi stated, would allow ECB to purchase "unlimited" amounts of short-term government bonds among the distressed countries in the euro area. Unlimited was a word never before used by ECB, and the market highly approved of this ECB statement regarding its new liquidity program.

Finally, by using the same procedure, we identified the outliers for the short-term component.

[32] http://finans.dk/artikel/ECE4796514/euro-krisen_tager_til_efter_ecb-skuffelse/?ctxref=ext

[33] https://www.ecb.europa.eu/press/key/date/2012/html/sp120726.en.html

[34] http://www.ecb.europa.eu/press/pr/date/2012/html/pr120906_1.en.html

Figure 22. List of outlier events only using principal component on Short-term

Date	Prin Short STD	Event
12.03.15	**-2,52**	**Lars Rhode speaks in London, says peg is "indestructible"**
05.02.15	**-2,11**	**NB lowers an already negative interest rate unilaterally**
03.02.15	**-1,84**	**Danish Prime Minister makes a public statement about the euro-peg**
30.01.15	-2,59	NB recommends to stop Issuing Danish Gov. Bonds
19.01.15	**-1,97**	**NB lowers an already negative interest rate unilaterally**
06.10.11	2,06	ECB announces liquidity programs. BoE announces additional QE
25.08.11	**-1,90**	**NB lowers interest rate unilaterally**
27.04.11	**1,81**	**Fed FOMC meeting: QE2 unchanged**
03.03.11	4,59	ECB surprisingly expresses a rate hike coming next month
02.04.09	2,86	ECB hints at unconventional measures to be introduced next month. ECB & NB lower interest rates

Only four events are found to be the same as in the All- and Long-term analysis, while six additional events result in a standard deviation greater than 1,5. Not surprisingly, the period where the euro-peg was under pressure represent 50% of the outliers found in the short-term component. Both the Danish Prime Minister and Danmarks Nationalbank's chairman, Lars Rhode, publicly stated that the euro-peg was indisputable during this extraordinary period. Still, we are more concerned with the outliers found in *All* and *Long*.

18.9. Correlation analysis:

Table 23. Outlier correlation analysis, between Danish Treasury bond measured by the principal component of Spanish Government bond measured by principal component.

The table below is the measures of correlation between the eigenvector products of Danish Treasury bond changes in yield and Spanish Government bonds yields, on event days that were deemed outliers with a 1,5 standard deviation change in either direction for either of the countries. The Full period in column a includes 26 observations. 1st period in column b includes 18 observations. 2nd period in column c includes 7 observations. 3d period in column d includes 3 observations. In parenthesis are the P-values corresponding to the Pearson correlation statistics, with fisher's z transformations. They measure the null hypothesis that the correlation could be equal to zero.

	Full period 2006-2015 a	**1st Period 2006-2009** b	**2nd period 2009-2013** C	**3rd period 2014-2015** d
Correlation between Danish & Spanish yields	-0,141 (0,495)	0,757** (0,048)	-0,305* (0,097)	-0,975 N/A

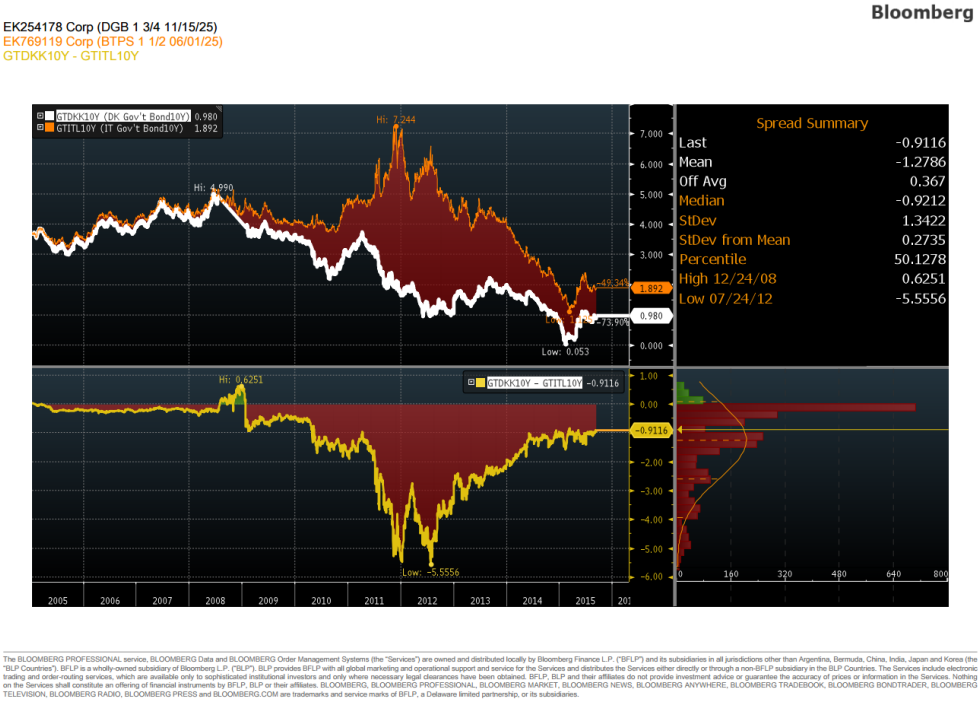
In table 23, the correlations to prove the previous outlier analysis are listed. There are 4 different correlations corresponding to the time periods used in the previous chapters. There are two insignificant correlations. The correlation for the full period and for the third period is both insignificant. We would have expected a positive sign during the full period. Still, the p-value of almost 50% shows that it is insignificant and could just as well be zero or positive. The 3rd period only had 3 outlier observations and is therefore very insignificant. In fact, the Pearson statistics returned no values for the estimates of significance. The result is therefore somewhat useless. However, the results in the second and first period are interesting to us. It shows that our results and interpretation in the outlier chapter seems to aggregately hold true. There is a strong positive correlation in the first period, during the great recession, where the changes in Treasury bond rates and Spanish government bonds seemed to co-move. This points towards our initial thoughts about the changes in the Treasury bond rates on the events during the Great recession, that there were dramatic falls and increases simultaneously in all economies during this period. This allows us to look past the results of the positive relationship between the stock prices and Treasury bond long-term rates in the recession period, and focus on the second period mid 2009 to 2013, where the results from the regression in table 8, 9 and 10 remained positive.

Above, in table 23, we find what was expected. From the first period during the regression to the second period, namely the European debt crisis, the correlation changes from heavily positive to negative. Both of the correlations are significant on the 10 percent level. The

negative correlation means that when Danish Treasury bond rates go up on basis of an event that is large in magnitude, the Spanish government bond rates decreases. This effect is potentially the same for all of the southern regions that suffer from economic distress. In order to support this claim we made a spread analysis between the Danish Treasury bond and the Italian government bonds to see if it looked similar to the analysis using Spain in figure 18.

Figure 19. Spread analysis between the Danish Treasury bond with 10 year maturity, and the equivalent Italian government bond.

Figure 19 presents a spread analysis between the Danish generic government bond with a 10 year maturity, and the Italian 10 year generic government bonds. The spread analysis in obtained from Bloomberg (R). The graph in the top represents the nominal rates of the respective government bonds. While the bottom graph presents the Danish government bond less the Italian.



The spread analysis in figure 19, is almost identical to the spread analysis in figure 18, comparing Spanish government bonds rather than Italian.

This finding supports our hypothesis that a potential reason why there is a positive relationship between the long-term Treasury bond and the Danish stock market is because there are movements of capital within the Eurozone, on event days.

To further investigate, we also found correlations in the second period between Spanish Government bonds, Danish Treasury bonds, the OMX C20 index and the EuroStoxx50. This can be seen below in table 24.

Table 24. Correlation in the second period, mid 2009-2013.

The table below represents the correlations between the Danish principal component for Treasury bonds with maturity 2-, 5- and 10 years denominated as DK PRIN. The principal component for the Spanish government bonds for maturities 2-, 5-, and 10 years maturity denominated as ES PRIN. And the Daily change in the OMX Copenhagen 20 and EuroStoxx 50 representing the 50 largest Eurozone stocks.

Second period, mid 2009-2013	DK PRIN	DK C20	ES PRIN	EUSTOXX 50
DK PRIN	1			
DK C20	0,56864	1		
ES PRIN	-0,30524	-0,31132	1	
EUSTOXX 50	0,65212	0,74588	-0,65433	1

We find that the changes in Spanish Government bonds rates are, in fact, negatively correlated with both the Danish equity prices and the European equity prices. This would indicate that on the days where ECB lowered uncertainty in the south, the share prices in the Eurozone went up. During the same event days, Danish long-term Treasury bond rates increased together with equity prices.

PART VIII - Discussion and Conclusion

20. Interpretation

In this chapter we will interpret the findings from our results through the various models outlined in Part VII, where we provided initial comments on the estimates, their significance and their direction, as well as some interpretation. In this chapter, we will try to put the results into context and give an overview of the findings and their potential links.

In our approach to determine the effects of the monetary policy currently used in the Eurozone, including Denmark, we set up a series of different models. They try to explain relationships between the Danish stock market, the Danish Treasury bond rates and the CIBOR rates. During our analysis, we came up with several results and due to the nature of these results, we decided to separate them into main results and secondary results. The main results are the direct results from our attempt to uncover the reason why we found a positive relationship between the Danish Treasury bond yields and the Danish stock market, which is

contradicting to Bernanke & Kuttner (2005) and Wright (2012). The secondary results are discoveries not directly explaining this relationship, but rather attempts to examine the channels through which the Danish market is affected by monetary policy, and results analyzing the drawbacks of our models and data.

In this chapter we abbreviate Treasury bond with TB.

20.1 Secondary results:

20.1.1. Results from analysis using midcap

Due to the recent creation of a new large cap market index in Denmark, which we were unable to get sufficient data of, we had to use the slightly outdated OMX C20 as a market index. This index relies heavily on the evolution of the Novo Nordisk A/S B-share, one of the world's biggest pharmaceutical companies, providing a possibly skewed picture of the overall market. To minimize this effect we compared CIBOR and TB to the smaller indexes on the NASDAQ Copenhagen exchange. Accordingly, this could provide us with some explanation of the difference between the effects of changing monetary policies on small and large companies, i.e. the risk-taking channel.

The results from the TB rate changes show that the regression between Midcap and TB changes is significant on the 1 percent level. In addition, the resulting estimates are quite similar in size to the one using C20 as market index. The long-term interest rate changes has a slightly larger positive effect on the C20 than it does on the Midcap. Still, they are not statistically significantly different given our data set. A potential difference could, however, be due to differences in the effect of small companies versus large companies, or because of Novo Nordisk's possible influence on the C20. The latter will be further investigated in the following pharmaceutical index chapter.

In order to further investigate the effect between large and small companies and get an idea whether there could be a difference, albeit not statistically significant given our dataset, we took a look at the spread between the returns of C20 and the Copenhagen Small Cap on event days, using a so-called SMB; "Small minus big". In contrast to findings by Wright (2012), that size does not seem to be a priced risk factor in the stock market, our estimates were statistically significant. It had a positive estimate on the short-term TB rates and negative on long-term TB rates. This shows that the spread between the small cap index and the C20

increases as short-term TB rates increase and decrease as long-term TB rates increase. The estimate is in absolute terms larger in the long-term TB rates than the short-term. So if there is a positive shift of one standard deviation in both short and long-term interest rates, the spread would decrease. Whereas, a change in the yield curve where short-term rates would go up but long-term rates would stay the same, the spread would actually decrease. This emphasizes the idea that there are differences between how monetary policy effect small and large companies, respectively. At least this seems to be the case in Denmark. When interests are high, the spread between the yield of small companies and large companies diminish, surprisingly contradicting the existence of a risk-taking channel. If the risk-taking channel was to be proved, the spread should increase as interest rates go up. This could in part be biased because of inconsistent variance, and is in fact only a result that gains significance in the early part of our dataset, namely the recession. In fact, when we run the regression using only the years of 2014 to 2015, where we also found a negative relationship between stock markets and long-term TB rates, we find that there is a positive relationship between a shift in interest rates and the spread between small and large companies. The regression can be found in Appendix 1. These findings were not statistically significant, but they do point towards the same idea as in the main results: that there is a problem with heteroskedasticity throughout the period. We will comment further on this in the later chapter concerning the main results.

All of the results comparing CIBOR rates to Midcap and Small Cap proved insignificant. Even the analysis of spread between C20 and Small Cap couldn't be explained using CIBOR rates in our *All event* model.

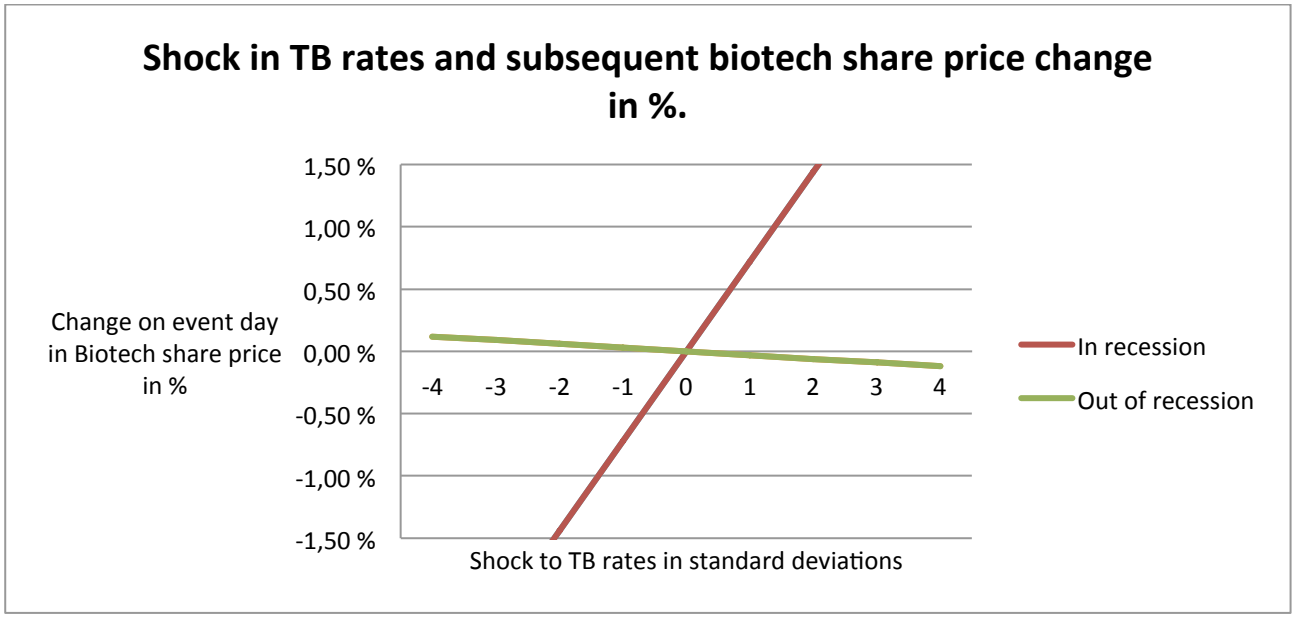
20.1.2 Results from using pharmaceutical industry index

We find that interest rates have very little effect on the pharmaceutical industry, with Novo Nordisk in front. Both the results from using Danish TB and CIBOR rates rendered very little significance to the pharmaceutical index and/or Novo Nordisk alone. If there exist a bias in C20 from Novo Nordisk, it is likely to pull it towards being less significant than it actually is. However, it is potentially more obvious that there are larger risks involved in biotech contrary to pharmaceutical, as we deem it fair to claim that small businesses, all else equal, are more risky than large. Moreover, Biotech is basically a research company with no assets until the product is marketed or proven to work. If we look at the results from the biotech and TB rate changes in table 11. In the biotech index comparison to the TB rate changes on all

events, we see a negative estimate on the cross-variable between the recession dummy and the long-term TB rates, while the estimate on the long-term TB rates is positive. The negative estimate on the cross-variable is, in absolute terms, larger. This means that when we are not in recession the effect of an increase in long-term TB rates is a reduction in the value of biotech companies, and vice versa for a decrease, depicted in Figure 19.

Figure 19. Effects of a monetary policy shock in the form of standard deviation changes in Danish TB rates on the value of a Danish biotech index.

Figure 19. Graph made on the basis of the regression results in table 6. The red line, "In recession", is a representation of a multiplications of the standard deviation change on the x-axis with the estimate on long-term TB rates in column d of 0,0072 or 0,72%. The green line, "Out of recession" is a representation of the multiplication of the sum of the cross variable in column d, of -0,75% and the long-term estimate of 0,72% with the change in TB rates in standard deviation of the x-axis.



But if we are in recession, the value of biotech companies increase as there is an increase in the long-term TB rates. When we are not in recession, on the other hand, there is a tendency to look for returns. When interest rates go down, outside of recession, investors are more willing to shift to risky investments such as biotech. If we on the other hand look at the larger pharmaceutical companies as a whole, they are not affected by changes in interest rates, possibly due to very low market exposure and risk. In the WHO report from 2010, they argue that the consumption of medicine did in fact not decrease during the great recession

Yet, when we are not in recession, the biotech index has a negative relationship to changes in long-term TB rates, thus pushing up the price as the interest rates go down. This serves, amongst other things, as a hint towards the existence of a risk-taking channel. Investors will

take on riskier assets in the search for yield as interest rates go down, given that the economic environment allows it.

20.1.3. CIBOR rates results and the liquidity premium

All of the CIBOR rates models have been statistically insignificant. However, a regression not using hetroskedasticity robust standard errors yielded a very significant result. The results can be found in Appendix 2. This leads us to believe that there was a massive co-movement during the onset of the recession. It could potentially be due to a large worldwide lack of liquidity during the Great Recession, pushing everything in the same direction. This might also explain why we get a massive positive relationship between long-term TB rates and the stock market in the first period from 2006-2009 in table 18.

The paper by Musto et al. (2015) look at the differences in prices of US Treasury notes (medium term) and Treasury bonds (long-term), and their spread during the great recession. They argue that the huge spike during the great recession was due to a large sudden lack of liquidity. In another paper by Dick-Nielsen et al. (2010), the illiquidity before and after the subprime crisis is examined. They use a principal component with several liquidity measures in order to make it robust. Their measure for liquidity is the spread between a very liquid bond and an illiquid bond. They find that there was in fact a huge change in the spread during the onset of the crisis. Unfortunately, we were unable to obtain or create a sufficient measure for the liquidity in the Danish bond and stock market at the time on the great recession, due to limited availability of sufficiently detailed bond volumes and prices at that time. Instead of creating a measure for the liquidity of the bond markets and stock markets, we created a dummy using a period that corresponds to the graph presented in the paper by Dick-Nielsen et al. (2010). More specifically, the graph in question is a time series of the spread of investment grade bonds and speculative grade bonds. We decided on the basis of these two graphs that the period with the highest liquidity premium would be roughly between mid 2008 until mid 2009. We went on to test whether the relationship between the CIBOR rates changes on event days was different during this period compared to the remaining period. The dummy variable was crossed with the principal component for CIBOR. The results showed that, in fact, the only time the changes in CIBOR on event days were significant, was during the period of very high liquidity premiums. The remaining events and subsequent changes in the CIBOR rates have no effect on the stock market. It is not evidence that the lack

of liquidity was in fact the reason we got a statistically significant relationship but potentially an explanation. However, it serves to add that it was presumably something besides signaling and the balance channel effects that created the significant relationship, because it wasn't present in the remaining of the data period. Graph can be seen in Appendix 3.

20.1.4. Interest rate channels:

To test whether the interest rates set by Danmarks Nationalbank influences the market rates we tested the hypothesis of an interest rate channel. So in order for them to influence through deposit and lending rates, these have to function as an alternative rate. The rates set by Danmarks Nationalbank are only available to the large bank institutions (Drejer et al. 2011). A test of whether they actually affect the market rates would in theory require there to be a difference in what interest rates are offered by large banks and small banks. We cannot within the constraints of our model test if the rate changes affect the offered interest rates by the banks. However, we can measure the effect on the price of differently sized bank shares given a rate hike or a rate cut. This is reasonable because there in theory must be a strong relationship between the profitability of a bank and the interest rates they receive- and offer. Additionally, the interest rate to which the banks can loan money at, affect their balance sheet and thus their valuation (Schildbach 2012).

The results from the analysis of Treasury bond rates provide some evidence that there is, in fact, an interest rate channel that affect small banks differently than large banks. The effect on both small- and large banks is significant. An increase in the long-term interest rate, increases the value of the shares of either bank size, and an increase in the short-term rate has a negative effect on the price of both bank sizes. They are, nevertheless, quite different in magnitude. The effects from an interest change has a lot more influence over the valuation of a large bank than it does of the small bank, almost 3 times as much per standard deviation change in the interest rate.

20.1.5. Signaling channel and balance channel

In the paper by Askjær et al. (2011), it is hypothesized that the way Danmarks Nationalbank interest rates affect the market rates in Denmark, is through two channels. An interest rate channel and a credit channel are mentioned. The interest channel has been discussed in the chapter above and we found some evidence that could back the hypothesis of an interest rate channel.

The credit channel, as explained by the paper, is: "According to the hypothesis of a credit channel, a change in the monetary-policy interest rates could affect the total supply of loans. Banks will be forced to reduce their lending due to worsened fund reserves since an increase in interest rates will lower the value of their assets."
Specifically, they call the effect of lowered asset value the balance channel when pointing out the effects hereof. They find no proof of a credit channel nor a balance channel. In accordance with the paper by Askjær et al. (2011), one could argue that the fact that pharmaceutical companies who have large intangible assets are almost unaffected by TB rate changes, points towards the absence of a balance channel, whereas biotech firms are significantly affected by changes in TB rates, despite having limited assets. It is of course hard without further research to isolate the effect, because the effects of the risk-taking channel should mitigate this effect if not completely overshadow it.

20.2. Main results

In this part of the interpretation chapter we will be discussing the findings and results from our main results. These results will be the results from our attempt to explain what happens when news of monetary shocks reaches the Danish Treasury bond and consequently the stock exchange within the framework of the Danish krones' peg to the euro. It is mentioned throughout this paper that according to Bernanke & Kuttner (2005) an unanticipated decrease in the Federal Funds rate increases stock prices. Wright (2012) finds the same relationship between loose monetary policy and stock prices. The basis for the causal relationship between equity prices/stock prices and the monetary policy has been heavily debated by many economists through time. While most economists agree that money are non-neutral in the short run, whether or not they are neutral in the long run is still subject to much controversy. Money non-neutrality theories state that money supply or monetary policy can have an impact on the real economy e.g. wages, output and thus stock prices, which are a reflection hereof (Bodie et al. 2011). Some economists argue that the causal effect goes the other way, and that in fact real economic factors drive the monetary policy and not the other way around as discussed in Bernanke & Kuttner (2005). We have also provided arguments for why the equity prices could go both up or down after a monetary policy announcement. Either way, in our model we look at events as exogenous and measure how the equity prices respond to news to monetary policy changes or outlook. We believe that sufficient economists such as

Bernanke & Kuttner (2005), Wright (2012) and others' arguments, warrant our assumption of the causal relationship that appears when changes in monetary policy affect equity prices.

Another way to look at it, is to view monetary policy changes as lowering risk by helping distressed economies, for example by asset purchases or sufficient and extraordinary liquidity provisions. According to Bloom (2012), uncertainty lowers economic output. All else equal, a lower economic output must affect equity prices, as they are, according to efficient market hypotheses, pricing in all public information. You can then argue whether markets are efficient, but it is not unfair to assume that the European money- and equity markets are at least semi-strong in the efficient market framework. Lowering the uncertainty, then, should, all else equal, cause an increase in equity prices.

Denmark is as a small net-exporting EU member, whose main export recipients are all located within the European Union. The Danish market is therefore very dependent on the general economic environment in EU. Although Denmark is not part of the Eurozone, the Danish krone is pegged to the euro with a very narrow band. It is therefore fair to assume that Danish equity prices are heavily dependent on the uncertainty in the remaining EU countries, with the Eurozone countries in particular.

20.2.1. All Events Model

When we set up a regression to look at the relationship between the Treasury bonds and the equity prices, we found, to our surprise, a significantly positive relationship. An increase in the Treasury bond rates coincided with an increase in Danish equity prices. According to both Bernanke & Kuttner (2005) and Wright (2012), it should be the other way around. It also contradicts the several reasons for why a looser monetary policy should boost stock prices. For instance that Treasury bond rates are used as a substitute to the risk free rate in asset pricing models, as well as affecting the balance sheet of companies. It could mean that there is a signaling effect that is significant and large within the EU. We found that this signaling effect, albeit definitely significant and returning different estimates depending on economic situation, is potentially not the only reason why this positive relationship between monetary policy and subsequent Treasury bond changes and the equity prices would emerge. Why would the signaling effect be so predominant in the EU and not in the US? When we used events where new information by the US Federal Reserve was the origin of a change in the

Treasury bond rates, we got results corresponding to that of the previously mentioned economists. We therefore proceeded with the hypothesis that it might be factors within the European Union, particularly the euro area, which created this significant and contradicting result. We set up to figure out if the reason why equity prices increase as Treasury bond increases, was in fact due to the heavy integration of the Danish krone to the peg and the Eurozone. So in other words, money would flow between economies depending on where the risk/reward ratio was in fact best. Since the introduction of the euro and Denmark's corresponding euro-peg, much interest rate uncertainty has been removed, and money can flow freely within the European Union. This leaves investors completely indifferent between investing in southern Europe or Denmark if the risk/reward is similar. When the investors are indifferent between the two, and an announcement that changes this perceived risk/reward ratio instantly, we would assume that people would move their money to where the better reward-to-risk ratio exists, immediately following the announcement. This can create great opposite movements of capital between the relative risky countries and the countries perceived to be less risky. Whilst removing uncertainty mainly concern the southern parts of Europe, the ECB lowers uncertainty in Europe as a whole, due to the large degree of integration. The ECB creates incentives for investors to move large sums into countries that offer significantly higher returns than that of their northern counterparties. At the same time, the lowered uncertainty increases the outlook on Europe as a whole, which creates an increase in the equity prices in cohesion all over Europe including Denmark, whose large exposure to the other European economies makes it very vulnerable to changes outside its borders, particularly changes within the EU. However, the money that flows into the south and reduces their interest rates, in part come from the sale of Danish Treasuries, thus increasing the yields on Danish Treasury bonds. Meanwhile, Danish equity prices are simultaneously increased, due to the newly decreased uncertainty across the Eurozone. To exemplify, we set up a series of equations to illustrate the course of events of our main finding..

Prior to any monetary shock, a market equilibrium such as equation (6) exists. In the period between mid 2009 and 2013, the equation had two attributes. The Government bond yield in Spain is larger than its counterpart in Denmark, The Treasury bond. Thus, $ES_r > DK_r$. Another attribute is that the risk in Spain is larger than the risk in Denmark. The risk includes several

types of risk, although mainly credit risk since the euro-peg has effectively eliminated the exchange rate risk. Thus $Risk_{ES} > Risk_{DK}$.

$$\frac{ES_r}{Risk_{ES}} = \frac{DK_r}{Risk_{DK}} = equilibrium \tag{6}$$

When an announcement from the ECB is published, stating that they plan to go forth with monetary policy in an attempt to stabilize the distressed economies of the Eurozone, the risk in Spain is reduced. And suddenly the equation on the left seems favorable in terms of reward to risk, as seen in equation (7).

$$ECB\ news \rightarrow \frac{ES_r}{Risk_{ES}\downarrow} \neq \frac{DK_r}{Risk_{DK}} \rightarrow \frac{ES_r}{Risk_{ES}} > \frac{DK_r}{Risk_{DK}} \tag{7}$$

As investing in Spain becomes more favorable than investing in Denmark, money start moving from Denmark to Spain until a new equilibrium is reached as shown in equation (8). When money moves from Denmark to Spain it will, through the forces of supply and demand, increase interest rates in Denmark while simultaneously reducing interest rates in Spain.

$$\frac{ES_r}{Risk_{ES}\downarrow} > \frac{DK_r}{Risk_{DK}} \rightarrow \frac{ES_r\downarrow}{Risk_{ES}} = \frac{DK_r\uparrow}{Risk_{DK}} = new\ equilibrium \tag{8}$$

While reducing the risk, or uncertainty, in Spain and the other southern distressed European economies, the ECB reduces risk in the highly integrated EU economies. This reduced uncertainty, according to Bloom (2009), must all else equal increase economic output, which investors reward by buying up stocks and thus pushing the prices of equities upwards. This creates a positive relationship between the Treasury bond rates and the equity prices we found in Denmark. According to this logic, it must create a negative relationship between Danish equity prices on event days and Spanish government bonds.

To test this hypothesis we looked into individual events that had large effects on the Danish and Spanish principal components for Treasury bond and government bond rates, respectively.

We chose days with a reaction of more than ±1,5 standard deviation during all periods and looked qualitatively at what happened. We found that in fact some of the days that had the largest influence on the bond rates were days on which the ECB used monetary policy to stabilize the markets of the Eurozone xountries in distress. For our purpose, it is the outliers for *All* and *Long* that are of interest. During the period of 2009-2013, when ECB hints at, announces or reveals details concerning unconventional liquidity programs or calls for government-backed guarantees to the European bailout fund, all measures assumed to enhance stability in the distressed economies of the Eurozone, money seem to pour into the government bonds of the now less uncertain government bonds of southern Europe at the expense of Danish Treasuries. Similarly, when events increase the risk in the region, as when ECB disappointed the market on its press conference, or when violent anti-austerity protests occurred in Spain and Greece, money appear to flow the other way. Most of the outlier events are self-evident and need no further elaboration. Still, we believe that the two subsequent ECB press conferences of August and September of 2012 clearly illustrate this reward/risk adjusted money flow. On August 2nd, ECB greatly disappoint the market with its vague talk of "maybe" implementing the OMT program, shortly after publicly stating it would do "whatever it takes" to save the euro. However, on the following press conference, on the 6th of September, ECB revealed the details of this OMT program which led to a Europe-wide jump in equity prices and reductions on European Treasury yields. This program would allow ECB to purchase "unlimited" amounts of short-term government bonds among the distressed economies of the euro area. Unlimited was a word never before uttered by ECB. Most of the other outliers support the notion that capital flight occurs due to changes in perceived political- and economic uncertainty.

To emphasize this finding, we looked at the correlations between the Spanish government bonds and Danish Treasury bonds on the outlier days. In particular, we looked at the days in the second period from our analysis, the period between mid 2009 and 2013. We found that the correlation was, in fact, significantly negative on a 10 percent level of significance. We went on to test whether that would also mean that the Spanish government bonds on these days were negatively correlated with the Danish equity prices and the equity prices of the Eurozone represented by the EuroStoxx50, and found that, in fact, they were.

Since the outlier events, or events that has a large impact on the Treasury bond rates, must by its response be unanticipated or surprising, yet the two outlier exclusion model and the model including all events are very similar either our events are overall unanticipated, or the effect remains the same for all levels of anticipation, however we cannot distinguish the two.

20.2.2. Unconventional Model

Like Wright (2012); Glick & Leduc (2012); Fratzscher et al. (2014) and several others, we investigated what unconventional monetary policy did to equity prices. We applied this to the Danish central bank and Danish equity prices, which, to our knowledge, has never been done before. By assigning our defined unconventional measures by Danmarks Nationalbank to a dummy variable, we got a significant negative relationship between Treasury yields and Danish equity prices, represented by the C20 index. On this basis, the inflationary forces seem to overshadow the deflationary forces that arise when the unconventional policy is announced. Precisely which of the inflationary forces that is the prevailing one, is something we have not investigated in further detail. But when negative interest rates are imposed by the central bank and negative rates are prevalent in the money market, it would be a reasonable assumption to state that the risk-taking channel is at work. It is also within the sphere of reason to assume that the discount factor used to valuate equities is lowered, thereby increasing the stock prices. Given the very low inflation in Denmark in recent years, we dismiss inflation as a cause that has pushed equity prices higher. Considering the results found in this model, the results from the model using only ECB's announcements regarding unconventional monetary policy are a bit surprising. Since maintaining the euro-peg is the main objective in Danish monetary policy, and we assume that markets are efficient, we would expect this model to provide some significant results. The event days used in this model, however, differ substantially from the NB Unconventional model. It consists of 24 events, with 19 of them taking place from mid 2009 – 2013, and only 4 in the 2014 – 2015 period. In the NB unconventional model, on the other hand, 5 of its total 9 events take place during the period between September 2014 and February 2015. This is a time period when the European debt crisis has more or less been “resolved”. At least market participants regard the debt of the southern European countries as much safer, reflected in the spread with their Danish counterparts. Furthermore, during the beginning of 2015, the DKK/EUR was under

tremendous pressure due to Switzerland's abandonment of their euro-peg, and the ECB's QE program.

Given the size and openness of the Danish capital markets, the use of intraday data would have been highly desirable in analyzing these unconventional monetary policy events implemented by Danmarks Nationalbank and their effects in more detail. Nevertheless, not only is our finding in line with conventional wisdom and the majority of research concerning unconventional monetary policy and its effect on equity prices, it is consistent with the development in Danish equity valuations in the period 2014-2015. As we pointed out earlier in the assignment, the valuations of Danish equity were not only far above the average for the decade ending with Q1 2015, they were significantly higher than the post-crisis highs reached in 2007. Even if the central bank of Denmark feared that its policy of negative interest rates contributed to overvalued equity valuations, its historical dedication to the peg, which it has poured so much effort into maintain in order to appear as a trustworthy and reliable institution, would have made Danmarks Nationalbank, we believe, unable to prevent or put a stop to it. Without a revolutionary alteration in current Danish monetary policy, the euro-peg will be maintained, it seems, at all costs. Again, we must stress that we do not imply that there is a current bubble in Danish equities, or that an uncompromising commitment to the euro-peg is a bad policy to follow. Rather, we simply try to detect economic relationships using objective data.

21. Conclusion

In this assignment we have shown a significant positive relationship between the long-term Danish Treasury bond rates and the Danish equity prices through the years 2008-2015 on monetary policy event-fays. In short, when Danish Treasury bond rates increase on basis of information given by the ECB and Danmarks Nationalbank, the equity prices of the OMX C20 and the Midcap increase as well. We did this by regressing Treasury bond rates, and to a certain extent CIBOR rates, on changes in equity prices. We base this on exogenous event days, relating to any information given by the ECB and the Danmarks Nationalbank.

Our main finding contradicts the results of several researchers, amongst them Bernanke & Kuttner (2005) and Wright (2012). We continue to investigate what might create such a relationship, and find that in the later years of 2014 to 2015 the effect is, in fact, similar to the

findings of Bernanke & Kuttner (2005) and Wright (2012). In this period, when long-term Treasury bond rates decrease, Danish equity prices increase. Most of the unconventional monetary policy done by the Danmarks Nationalbank is done in this period, and we find that the unconventional events, events in which the zero lower bound was reached or breached, seemed to have a greater negative relationship to the equity prices. This finding fits a majority of recent research regarding unconventional monetary policy and its effect on equity prices

The two periods of The Great Recession (2006-2009) and the European Debt Crisis (mid 2009 to 2013), respectively, still remain contradictory to Bernanke & Kuttner (2005) and Wright (2012). We hypothesize that the results occurring during the Great Recession, where there is a positive relationship between long-term Treasury bond rates and equity prices, is due to a worldwide lack of liquidity. And to some extent test and acknowledge that during this period of recession the long-term Treasury bond also functioned as a signal for investors.

We further tested a second hypothesis, that the reason why the changes in long-term Treasury bond rates has a positive effect on the equity prices in the period of the European Debt crisis, was due to a massive capital movements between the most affected countries and the least affected countries, immediately after news that mitigated the uncertainty about the distressed Eurozone economies were released. We believe this to be the case, in part, due to the large spread between mainly southern government bonds and Danish Treasury bonds that appeared during the European Debt crisis. This would create a large incentive for investors to move their money as soon as uncertainty was reduced, which created a favorable return-to-risk ratio immediately after news about monetary policy changes reached the market. However, because of the large amount of intra-trade within Europe and the Eurozone, the reduced uncertainty in the distressed regions would reduce overall uncertainty, thereby creating a positive response in the equity markets. We test this by looking into specific dates on which the changes in Treasury bond rates and Spanish government bond rates were particularly high. We find that during some of these days, the Spanish government bond rates were lowered, the Danish Treasury bond rates increased, and equity prices in Europe and Denmark increased. We proceed to look at the correlations between all the events that created a large impact on the Treasury bond rates and Spanish government bond rates, and see that in fact the correlation matrix corresponds to our hypothesis, that on these days large portions of money must flow from Denmark and potentially other countries to the southern

more distressed regions during the European Debt Crisis. An additional finding that support this claim, changes in the Treasury bond rates on basis of information given by the Federal Reserve, did not, in fact, contradict Bernanke & Kuttner's (2005) and Wright's (2012) findings. This supports the notion that when the risk in Europe is reduced, the positive relationship between Treasury bond rates and equity prices in Denmark appear, and since FED does not do monetary policy in order to reduce European countries uncertainty, this should emphasize our hypothesis.

We believe that the model we created is to a large extent robust, as the effects from our analysis of the specific large-impact days, the outliers, correspond to the findings in our regression analysis. At the same time, our outlier exclusion mode returned the same result. We cannot say anything about whether or not our events were anticipated, but note that events with large effects on Treasury bond rates were probably not anticipated.

Due to our amount of results, we also investigated something that resulted in "secondary results". We tried to determine not just what happened with Danish equity prices when news about monetary policy reached the economy, but also how they were affected. We have discussed the existence of a risk-taking channel, a balance channel, a signaling channel and an interest rate channel. We rely heavily on previous research to establish the causality between the effect of monetary policy on market interest rates, but find that there is in fact potentially an interest rate channel in play. We use the risk-taking channel, the balance channel and the signaling channel as basis of a discussion of how the interest rates affect equity prices. Using a biotech index as dependent variable, we test if there is a difference in the response of a monetary policy change on biotech companies, and find that the biotech index respond differently in and out of recession. Even though this could be because of a lack of liquidity, we also assert some of it on the existence of a signaling channel. We use indexes of banks of different sizes to test if they reach differently to news concerning monetary policy, and find that they both have significant reactions. The large banks, however, seem to be more affected in magnitude by monetary news, and hence changes in Treasury bond rates. We cannot say whether this is because there is a difference between how the monetary news affect large companies more than small companies, or if this is in fact due to the existence of an interest rate channel. However, since there also exists a difference in the way biotech and pharmaceutical companies react to monetary news, and thus Treasury bond rates, we find, in

contrast to Wright (2012), that size is potentially a priced risk factor within the Danish monetary policy framework and equity markets.

We must stress, however, that monetary policy, both conventional and unconventional, even though significant, still only explain a very small portion of the variation in equity prices. And even though we have tried hard to account for any possible shortcomings in our model, we realize that there could be issues that we did not account for. We have in this assignment only compared Denmark to Spain, and briefly showed how the spread between Danish Treasury bonds and Italian government bonds has evolved through time. However, this model could be interesting to apply to other European economies. Further research on this subject, using intraday data is warranted.

Bibliography

Articles

Abildgren, K 2010, "Consumer Prices in Denmark 1502-2007", *Scandinavian Economic History Review*, vol. 58, pp. 2-24

Archer, D 2009, "Roles and objectives of modern central banks", *BIS: Issues in the Governance of Central Banks*, pp. 17-55

Barsky, R and Bogusz, T 2014, "Interest rates and asset prices: A primer", *Economic Perspectives, 4th Quarter,* Federal Reserve Bank of Chicago, pp. 139-148

Bernanke, B. S and Gertler, M 1995, "Inside the Black Box: The Credit Channel of Monetary Policy Transmission", *NBER Working Paper*, no. 5146

Bernanke, B. Sand Kuttner, K. N 2004, "What Explains the Stock Market's Reaction to Federal Reserve Policy?"

Blancheton, B 2015, "Central bank independence in a historical perspective. Myth, lessons and a new model", *Economic Modeling*, March 2015

Borio, Cand Zhu, H 2012, "Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?", *Journal of Financial Stability*, vol. 8, pp. 236-251

Caruana, J 2012, "Why central bank balance sheets matter", *BIS Papers,* No. 66, pp. 2-9

Cheng, Wand Angus, S D 2012, "The Cantillon Effect of Monetary Injection through Deficit Spending", *Discussion Paper 12/12*, Monash University – Department of Economics

Crowe, C and Meade, E. E 2008, "Central Bank Independence and Transparency: Evolution and Effectiveness", *Working Paper,* IMF – Research Department

Danmarks Statistik 2014, "Udenrigsøkonomi/Foreign Trade", vol. 65.

Dick-Nielsen, J, Feldhütter, P and Lando, D 2012, "Corporate bond liquidity before and after the onset of the subprime crisis", *Jounral of Financial Economics*, vol. 103, pp. 471-492

Drejer, P, kock, M, Rasmussen, M, Spange, M and Sørensen, S 2011, "Hvordan virker pengepolitikken I Danmark?", *Danmarks Nationalbank Monetary Review 2nd Quarter*, pp. 49-58

Day, W 1976, "A Reform of the European Currency Snake", *IMF Staff Papers,* vol. 23, pp. 580-597

European Central Bank 2011, "The Monetary Policy Of ECB", Frankfurt

Fatum, R and Pedersen, J 2009, "Real-time effects of central bank intervention in the euro market", *Journal of International Economics*, vol. 78, pp. 11-20

Fatum, R, Pedersen, J and Sørensen, P 2013, "The intraday effects of central bank intervention on exchange rate spreads", *Journal of International Money and Finance*, vol. 33, pp. 103-117

Feldbæk, O 2001, "Denmark in the Napoleonic Wars: A Foreign Policy Survey", *Scandinavian Journal of History*, vol. 26, pp. 89-101

Fischer, S 1996, "Why Are Central Banks Pursuing Long-Run Price Stability?", *Proceedings – Economic Policy Symposium – Jackson Hole,* 1996 edition, pp. 7-34

Fratzscher, M, Duca, M. L and Straub, R 2014, "ECB Unconventional Monetary Policy Actions: Market Impact, International Spillovers and Transmission Channels", presented at *the 15th Jacques Polak Annual Research Conference,* IMF, Washington November 13th-14th

Gambacorta, L 2009, "Monetary Policy and the Risk Channel", *BIS Quarterly Review, December 2009,* pp. 43-53

Glick, R and Leduc, S 2012, "Central Bank Announcements of Asset Purchases and the Impact on Global Financial and Commodity markets", *Journal of International Money and Finance*, vol. 31, pp. 2078-2101

Glick, R and Leduc, S 2013, "The Effects of Unconventional and Conventional U.S. Monetary Policy on the Dollar", *Working Paper,* Federal Reserve Bank of San Francisco

Greenwood, R andVayanos, D 2010, "Price Pressure in the Government Bond Market", *The American Economic Review*, vol. 100, pp. 585-590

Guidolin, M, Orlov, A and Pedio, M 2014, "Unconventional monetary policies and the corporate bond market", *Finance Research Letters,* vol. 11, pp. 203-212

Hermalin, B and Weisbach, M 2001, "Boards of Directors as an Endogenously Detmerined Institution: A Survey of the Economic Literature", *NBER Working Paper*, no. 8161

International Monetary Fund 2014, "Annual Report on Exchange Rate Arrangements and Exchange Restrictions", Washington

Ivrendi, M and Pearce, D 2014, "Asset prices and expected monetary policy: evidence from daily data", *Applied Economics,* vol. 46, pp. 985-995

Jensen, C and Spange, M 2015, "Interest Rate Pass-Through and the Demand for Cash at Negative Interest Rates", *Danmarks NationalbankMonetary Review 2nd Quarter 2015*, pp. 1-12

Joyce, M, Miles, D, Scott, A and Vayanos, D 2012, "Quantitative Easing and Unconventional Monetary Policy – An Introduction", *The Economic Journal,* vol. 122, pp. 271-288

Juster, F. T, Lupton, J. P, Smith, J. P and Stafford, F 2004, "The Decline in Household Saving and the Wealth Effect"

Krishnamurthy, A & Vissing-Jørgensen, A 2011, "The Effects of Quantitative Easing on Interest Rates", *NBER Working Paper,* no. 17555

Marcher, M 2010, "Danish Banking Before and After the Napoleonic Wars: A Survey of Danish Banking 1736-1857", *Monetary Boundaries in Transition: aNorth European Economic History and the Finnish War 1808– 1809*, pp. 127-143

Obstfeld, M, Shambaugh, J and Taylor, A 2004, "The Trilemma in History: Tradeoffs Among Exchange Rates, Monetary Policies and Capital Mobility", *NBER Working Paper,* no. 10396

Rivolta, G 2014, "An Event Study Analysis of ECB Unconventional Monetary Policy", *Working Paper,* University of Milan – Department of Economics, Management and Quantitative Methods

Rogers, J, Scotti, C and Wright, J 2014, "Evaluating Asset-Market Effects of Unconventional Monetary Policy: A Cross-Country Comparison", *International Finance Discussion Papers,* number 1101

Rose, A 2011, "Exchange Rate Regimes in the Modern Era", *Journal of Economic Literature,* vol. 49, pp. 652-672

Schildbach, J and Lantz, S 2012, "Low interest rates pressuring US bank margins", *Research Briefing,* Deutsche Bank Research, Frankfurt

Schneider, B 2003, "Measuring Capital Flight: Estimates and Interpretations", *Working Paper,* Overseas Development Institute, London

Spange, M and Toftdahl, M 2014, "Fixed Exchange Rate Policy in Denmark", *Danmarks Nationalbank Monetary Review, 1st Quarter 2014,* pp. 49-60

Sørensen, A 2014, "Studies in central bank legitimiacy, currency and national identity", *PhD Series*, Copenhagen Business School – Doctoral School of Organization and Management Studies

Wright, J 2012, "What Does Monetary Policy Do To Long-Term Interest Rates At The Zero Lower Bound?", *The Economic Journal,* vol. 122, pp. 447-466

Wu, T 2014, "Unconventional Monetary Policy and Long-Term Interest Rates", *Working Paper,* IMF – Institute for Capacity and Development

Books

Bodie, Z, Kane, A and Marcus, A 2011, "*Investments and Portfolio Management"*, 9th Edition, McGraw-Hill, Singapore

Danmarks Nationalbank 2009, "*Monetary Policy in Denmark*", 3rd Edition, Rosendahls, Copenhagen

Grell, H and Rygner, E 2008, "*Makroøkonomi – Teori og Beskrivelser*", 2nd Edition, Limedesign, Copenhagen

Mises, Ludvig von 2009, "*The Theory of Money and Credit"*, Ludvig von Mises Institue, Auburn, Alabama

Petersen, C. V and Plenborg, T 2012, "*Financial Statement Analysis: Valuation – Credit Analysis – Executive Compensation*", Pearson, Harlow

Stock, J and Watson, M 2012, "*Introduction to Econometrics*", 3rd Edition, Pearson, Harlow

Svendsen, K. E, Hansen, S, Olsen, E, Hoffmeyer, E and Mikkelsen, R 2010, "*Dansk Penge Historie*" *vol. 1-6,* Danmarks Nationalbank, Copenhagen

Speeches

McAndrews, J 2015, "Negative nominal central bank policy rates – where is the lower bound?", *University of Wisconsin, Madison*, 8th of May 2015.

Rhode, L 2013, "Nationalbankdirektør Lars Rohdes tale ved Realkreditrådets årsmøde 26. september 2013", http://www.realkreditraadet.dk/Files/Filer/Aarsmoede/2013/Tale%20-%20Lars%20Rohde_%20Nationalbankdirekt%C3%B8r.pdf

Appendices

Appendix 1 - relating to results from midcap:

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.00008482	0.00004241	0.64	0.5365
Error	20	0.00132	0.00006601		
Corrected Total	22	0.00141			

Root MSE	0.00812	R-Square	0.0604
Dependent Mean	-0.00004524	Adj R-Sq	-0.0336
CoeffVar	-17959		

Parameter Estimates										
						Heteroscedasticity Consistent				
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	0.00080734	0.00189	0.43	0.6737	0.00136	0.59	0.5602	.	0
PRIN long STD	1	-0.00032800	0.00302	-0.11	0.9147	0.00320	-0.10	0.9193	0.78988	1.26602
PRIN short STD	1	0.00202	0.00192	1.05	0.3051	0.00187	1.08	0.2940	0.78988	1.26602

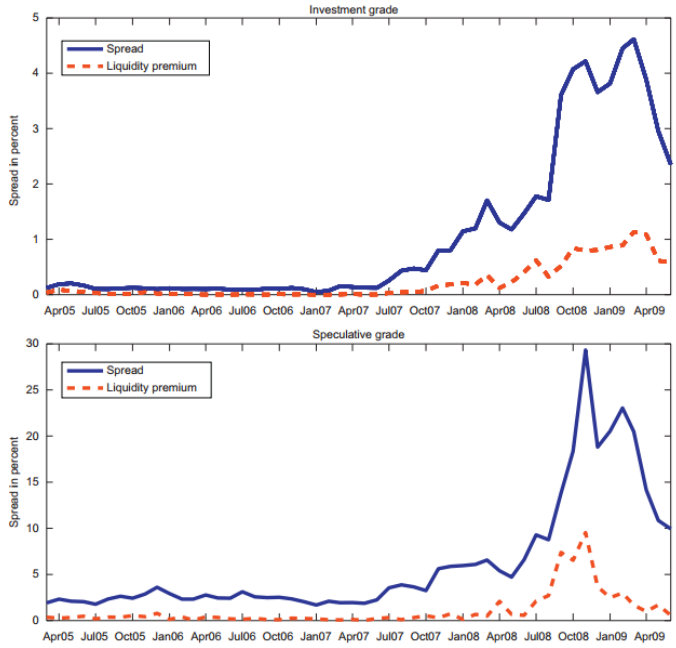
Appendix 2 - Refers to CIBOR rate calculations.

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.00398	0.00398	5.59	0.0197
Error	114	0.08123	0.00071257		
Corrected Total	115	0.08522			

Root MSE	0.02669	R-Square	0.0467
Dependent Mean	0.00323	Adj R-Sq	0.0384
CoeffVar	826.52455		

Parameter Estimates										
						Heteroscedasticity Consistent				
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	1	0.00292	0.00248	1.18	0.2422	0.00245	1.19	0.2361	.	0
PRIN STD	1	-0.00589	0.00249	-2.36	0.0197	0.00354	-1.66	0.0991	1.00000	1.00000

Appendix 3



Source: J. Dick-Nielsen et al. / Journal of Financial Economics 103 (2012) 4 71–492

"Liquidity premium and total spread for investment grade and speculative grade bonds. This graph shows for investment grade and speculative grade yield spreads the variation over time in the amount of the spread that is due to illiquidity and the total yield spread. On a monthly basis, the fraction of the yield spread that is due to illiquidity is calculated as explained in Section 4.3. This fraction multiplied by the median yield spread is the amount of the spread due to illiquidity and plotted along with the median yield spread. The data are U.S. corporate bond transactions from TRACE and the sample period is from 2005:Q1 to 2009:Q2."

Appendix 3 Speeches.

3a

	Main ECB announcements of unconventional monetary policy measures
Date	Decision
22-01-2015	ECB announces QE - 60 Billion Euros a month until Sept. 2016
15-01-2015	SNB drops peg
02-01-2015	Draghi hints at QE
04-12-2014	ECB Dissapoints market by not launching QE
04-09-2014	announcing it would buy bonds and other debt instruments primarily from banks in a bid to boost the availability of credit for businesses
05-06-2014	First *Major* CB to cut key rate below 0. + 400 B Euro in Cheap loans for Eurozone banks
07-10-2013	New record low interest rate, with the announcement of reducing them

06-09-2012	Publication of the details of the OMT program
02-08-2012	Vauge announcement of the OMT program
26-07-2012	"Whatever it takes"-speech
28-02-2012	Call for Bids of a LTRO with 36-month maturity
20-12-2011	Call for Bids of a LTRO with 36-month maturity
08-12-2011	Announcement of two LTROs with 36-month maturity
02-12-2011	Rumors about ECB's LTROs with 36-month maturity
03-11-2011	Publication of the technical details of the Covered Bond Purchase Program 2
25-10-2011	Call for Bids of a LTRO with 12-month maturity
06-10-2011	Announcement of the Covered Bonds Purchase Programme 2 and of two LTROs with 12-month Maturity
07-07-2011	Statement about the active implementation of the Securities Markets Programme
10-05-2010	Announcement of the Securities Markets Program
15-12-2009	Call for Bids of a LTRO with 12-month maturity
03-12-2009	Announcement of details on renancing operations (MROs conducted as xed-rate and full-allotment procedure for as long a is needed)
29-09-2009	Call for Bids of a LTRO with 12-month maturity
23-06-2009	Call for Bids of a LTRO with 12-month maturity
04-06-2009	Publication of the technical details of the Covered Bonds Purchase Programme 1
07-05-2009	Announcement of the Enhanced Credit Support programme and of the Covered Bonds Purchase Programme 1
15-10-2008	Announcement of several LTROs (3/6-monthmaturity, xed-rate full allotment procedure) and expansion of the list of eligible collaterals

3b

	Interest Rate Changes at ECB			
	Deposit Facility	**Main Refinancing Operations**		**Marginal Lending Facility**
Date		Fixed Rate lenders, fixed rate	Variable rate lenders, min. Bid rte	
04.09.2014	−0.20	0,05	-	0,3
05.06.2014	−0.10	0,15	-	0,4
07.10.2013	0	0,25	-	0,75
02.05.2013	0	0,5	-	1
05.07.2012	0	0,75	-	1,5
08.12.2011	0,25	1	-	1,75
03.11.2011	0,5	1,25	-	2

07.07.2011	0,75	1,5	-	2,25
07.04.2011	0,5	1,25	-	2
07.05.2009	0,25	1	-	1,75
02.04.2009	0,25	1,25	-	2,25
05.03.2009	0,5	1,5	-	2,5
15.01.2009	1	2	-	3
04.12.2008	2	2,5	-	3
06.11.2008	2,75	3,25	-	3,75
08.10.2008	3,25	3,75	-	4,25
09.10.2008	3,25	-	-	4,25
08.10.2008	2,75	-	-	4,75
03.07.2008	3,25	-	4,25	5,25
06.06.2007	3	-	4	5
08.03.2007	2,75	-	3,75	4,75
07.12.2006	2,5	-	3,5	4,5
05.10.2006	2,25	-	3,25	4,25
06.08.2006	2	-	3	4
08.06.2006	1,75	-	2,75	3,75
02.03.2006	1,5	-	2,5	3,5

3c

	FED Monetary Policy announcements
Date	Decision
12-12-2013	FOMC announces that it will reduce its purchases of longer term Treasuries and mortgage-backed securities by $10 billion dollars per month
19-06-2013	Bernanke suggests that the FOMC will moderate asset purchases later in 2013
22-05-2013	Bernanke rst signals that FOMC may reduce its quantitative stimulus
12-12-2012	FOMC extends monthly purchases to long-term Treasuries and announces numerical threshold targets
13-09-2012	FOMC announces that it will eexpand its QE policies by purchas g mortgaged-backed securities at a rate of $40 Billion a month
31-08-2012	Bernanke announces intention for further monetay easing
03-11-2010	FOMC announces it plan to purchase $600 billion of long-term US Treasuries by the end of the 2011 Q2
15-10-2010	Bernanke signals that monetary easing will be continued
21-09-2010	FOMC announces that it will roll over the Fed's holdings of US Treasuries
27-08-2010	Bernanke signals that monetary easing will be continued

10-08-2010	FOMC announces that it will roll over the Fed's holdings of US Treasuries
18-03-2009	FOMC announces that will purchase an additional $750 billion in agency MBS, up to an additional $100 billion of agency debt, and up to $300 billion of long-term US Treasuries
28-01-2009	FOMC indicates that it will incrase its purchases of agency debt and long-term US treasuries
16-12-2008	FOMC first mentions possible lon-term treasuries purchase
01-12-2008	Bernanke says FED could purchase long-term Treasuries in a speech
25-11-2008	Initial LSAP announcement

3d

Interest rate changes By the National bank of Denmark				
Date	**Type**	**Interest rate prior to change**	**Change**	**Interest rate after change**
05-02-2015	Indskud	-0,50%	-0,25%	-0,75%
29-01-2015	Indskud	-0,35%	-0,15%	-0,50%
22-01-2015	Indskud	-0,20%	-0,15%	-0,35%
19-01-2015	Indskud	-0,05%	-0,15%	-0,20%
04-09-2014	Indskud	0,05%	-0,10%	-0,05%
24-04-2014	Indskud	-0,10%	0,15%	0,05%
24-01-2013	Indskud	-0,20%	0,10%	-0,10%
05-07-2012	Indskud	0,05%	-0,25%	-0,20%
31-05-2012	Indskud	0,20%	-0,15%	0,05%
24-05-2012	Indskud	0,30%	-0,10%	0,20%
15-12-2011	Indskud	0,40%	-0,10%	0,30%
08-12-2011	Indskud	0,65%	-0,25%	0,40%
03-11-2011	Indskud	1,00%	-0,35%	0,65%
15-09-2011	Indskud	1,10%	-0,10%	1%
25-08-2011	Indskud	1,20%	-0,10%	1,10%
07-07-2011	Indskud	0,95%	0,25%	1,20%
07-04-2011	Indskud	0,70%	0,25%	0,95%
28-10-2010	Indskud	0,60%	0,10%	0,70%
14-10-2010	Indskud	0,50%	0,10%	0,60%
26-05-2010	Indskud	0,60%	-0,10%	0,50%
19-05-2010	Indskud	0,70%	-0,10%	0,60%
25-03-2010	Indskud	0,80%	-0,10%	0,70%

14-01-2010	Indskud	0,90%	-0,10%	0,80%
08-01-2010	Indskud	0,95%	-0,05%	0,90%
11-12-2009	Indskud	1,00%	-0,05%	0,95%
28-09-2009	Indskud	1,15%	-0,15%	1%
24-09-2009	Indskud	1,35%	-0,10%	1,25%
27-08-2009	Indskud	1,35%	-0,10%	1,25%
13-08-2009	Indskud	1,45%	-0,10%	1,35%
04-06-2009	Indskud	1,65%	-0,20%	1,45%
07-05-2009	Indskud	2,00%	-0,35%	1,65%
02-04-2009	Indskud	2,25%	-0,25%	2%
05-03-2009	Indskud	3,00%	-0,75%	2,25%
15-01-2009	Indskud	3,75%	-0,75%	3%
19-12-2008	Indskud	4,25%	-0,50%	3,75%
04-12-2008	Indskud	5,00%	-0,75%	4,25%
06-11-2008	Indskud	5,50%	-0,50%	5%
24-10-2008	Indskud	5,00%	0,50%	5,50%
07-10-2008	Indskud	4,60%	0,40%	5%
03-07-2008	Indskud	4,35%	0,25%	4,60%
16-05-2008	Indskud	4,25%	0,10%	4,35%
06-06-2007	Indskud	4,00%	0,25%	4,25%
08-03-2007	Indskud	3,75%	0,25%	4%
07-12-2006	Indskud	3,50%	0,25%	3,75%
05-10-2006	Indskud	3,25%	0,25%	3,50%
03-08-2006	Indskud	3,00%	0,25%	3,25%
08-06-2006	Indskud	2,75%	0,25%	3%

3e

Quarterly Press releases
Date
18-03-2015
10-12-2014
23-09-2014
17-06-2014
18-03-2014

11-12-2013
18-09-2013
12-06-2013
20-03-2013
13-12-2012
20-09-2012
14-06-2012
21-03-2012
15-12-2011

20-09-2011
16-06-2011
16-03-2011
09-12-2010
15-09-2010
10-06-2010
17-03-2010
10-12-2009
17-09-2009

11-06-2009
18-03-2009
11-12-2008
16-09-2008
12-06-2008

13-03-2008
18-12-2007
25-09-2007
30-05-2007
27-02-2007

07-12-2006
19-09-2006
07-06-2006

3f

Speeches	
Date	**Type**
25-03-2015	Nationalbankdirektør Lars Rohdes tale ved Realkreditforeningens årsmøde 25. marts 2015
01-12-2014	Nationalbankdirektør Lars Rohdes tale ved Finansrådets årsmøde
02-10-2014	Nationalbankdirektør Lars Rohdes tale ved Realkreditrådets årsmøde
08-09-2014	Nationalbankdirektør Hugo Frey Jensens tale ved Finansrådets direktørkonference
08-05-2014	Nationalbankdirektør Lars Rohdes tale ved Lokale Pengeinstitutters årsmøde
03-04-2014	Nationalbankdirektør Lars Rohdes tale ved Realkreditforeningens årsmøde
05-12-2013	Lars Rohdes tale ved Finansrådets årsmøde
26-09-2013	Nationalbankdirektør Lars Rohdes tale ved Revisordøgnet
26-09-2013	Nationalbankdirektør Lars Rohdes tale ved Realkreditrådets årsmøde
09-04-2013	Nationalbankdirektør Lars Rohdes tale på Realkreditforeningens årsmøde
29-01-2013	Nationalbankdirektør Nils Bernsteins tale ved DIIS Conference
03-12-2012	Nationalbankdirektør Nils Bernsteins indlæg på Finansrådets årsmøde
27-09-2012	Udtalelse af Nils Bernstein i forbindelse med Erhvervs- og Vækstministeriets redegørelse om Cibor
26-09-2012	Nationalbankdirektør Nils Bernsteins tale ved Realkreditrådets årsmøde
17-08-2012	Uddybningvedrørende CIBOR
30-03-2012	Udtalelse af nationalbankdirektør Nils Bernstein i forbindelse med åbning af 3-årige lån
29-03-2012	Nils Bernsteins tale ved Realkreditforeningens årsmøde
09-02-2012	Nationalbankdirektør Nils Bernsteins tale ved Europaudvalgets høring om finanspagten
25-01-2012	Nationalbanken støtter fusion mellem vestjyskBANK og Aarhus Lokalbank
14-12-2011	Nationalbankdirektør Nils Bernsteins tale: The European Debt Crisis – from a Danish Perspective
05-12-2011	Nationalbankdirektør Nils Bernsteins indlæg på Finansrådets årsmøde
12-10-2011	Nationalbankdirektør Nils Bernsteins indlæg ved Finansrådets direktørkonference
27-06-2011	Udtalelse af nationalbankdirektør Nils Bernstein vedrørende Fjordbank Mors
12-05-2011	Nils Bernsteins tale til Dansk Byggeris konference om produktivitet

27-04-2011	Nils Bernsteins tale ved Realkreditrådets årsmøde
30-03-2011	Nils Bernsteins tale ved Realkreditforeningens årsmøde
30-03-2011	UdtalelsevedrørendeCibor
03-03-2011	Nationalbankdirektør Nils Bernsteins svar på spørgsmål om belånning af rentetilpasningsobligationer
02-03-2011	Udtalelse af Nils Bernstein i forbindelse med ECBs 10 års fødselsdag
21-01-2011	Nationalbankdirektør Nils Bernsteins tale ved Realkreditrådets årsmøde
06-12-2010	Nils Bernsteins tale ved Finansrådets årsmøde
12-11-2010	Nationalbankdirektør Nils Bernsteins indlæg, Politikens konference 'Det lærte vi af finanskrisen'
02-11-2010	Nationalbankdirektør Torben Nielsens tale ved åbningen af Dansk Pengemuseums særudstilling
16-09-2010	Nils Bernsteins tale ved Dansk Arbejdsgiverforenings beskæftigelseskonference
02-09-2010	Nationalbankdirektør Nils Bernsteins tale på Finansrådets årsmøde
12-08-2010	Nationalbankdirektør Nils Bernsteins tale ved Nordic Statisticians Meeting, EigtvedsPakhus
08-07-2010	Nils Bernsteins tale ved 100-års jubilæum for DA-lønstatistik
14-06-2010	UdtalelsevedrørendeFærøernesLandsbank
22-04-2010	Nationalbankdirektør Nils Bernsteins tale ved Realkreditrådets årsmøde
24-03-2010	Nils Bernsteins tale ved Realkreditforeningens årsmøde
01-03-2010	Nationalbankdirektør Nils Bernsteins tale ved Finansrådets årsmøde
08-02-2010	Nils Bernsteins indlæg på VL døgn 2010, Dansk økonomi i globalt perspektiv
21-12-2009	Financial stability, the Danish perspective afTorben Nielsen
02-12-2009	Speech by Governor Jens Thomsen: Government Bond Markets in 2009
16-11-2009	Nils Bernsteins indlæg ved Arbejdsmarkedspensionskonferencen
16-11-2009	Nils Bernsteins indlæg ved konference i anledning af 125-året for ikrafttræden af sparekasseloven
16-11-2009	Nils Bernsteins tale på Finansrådets årsmøde
23-04-2009	Nationalbankdirektør Nils Bernsteins tale på Realkreditrådets årsmøde
31-03-2009	Nils Bernsteins tale på Realkreditforeningens årsmøde
02-02-2009	Nils Bernsteins tale på VL-døgn
22-01-2009	Nationalbankdirektør Nils Bernsteins indlæg ved Folketingets Europaudvalgs eurohøring
21-01-2009	Background to Jens Thomsens speech: Denmark's mortgage credit system and macroeconomic policy
07-01-2009	Debatten om forfald af ansvarlig lånekapital
08-12-2008	Nationalbankdirektør Nils Bernsteins tale på Finansrådets årsmøde
03-11-2008	Speech by Governor Jens Thomsen: Government bond market in light of the recent turmoil
28-08-2008	Nationalbankdirektør Nils Bernsteins tale til Dansk Industris erhvervspolitiske topmøde