ISCTE Business School
Instituto Universitário de Lisboa

THE MONETARY PASS-THROUGH EFFECT TO INTEREST RATES

Oskar Stavland Hjorth

Dissertation submitted as partial requirement for the degree of Master of Economics

Supervisor:
Prof. Sergio Miguel Chilra Lagoa, Assistant Professor, ISCTE Business School, Department of Political Economics

October 2017

ISCTE Business School
Instituto Universitário de Lisboa

THE MONETARY PASS-THROUGH EFFECT TO INTEREST RATES

Oskar Stavland Hjorth

Abstract

The Monetary Pass-Through Effect to Interest Rates

By Oskar Stavland Hjorth

The monetary pass-through effect to interest rates is a topic that have caught economists' attention for a long time. The matter did not receive less consideration during the financial chaos, which arose in the late 2007. How money market interest rates responded to a policy rate adjustment, was more crucial during the financial crisis than never before. Whether the financial crisis disturbed the policy rate pass-through effect was therefore a central question appearing in the aftermath of the crisis. In order to grasp the policy rate pass-through effect, recent studies highlight the importance of excluding monetary expectations. Interest rate reactions, due to policy adjustment, are likely to be mitigated if the policy change is correctly predicted by the market. By separating between the expected and unexpected portion of the Norwegian policy rate, I study one-day fluctuations in various Norwegian interest rates, before and after a policy rate announcement. Moreover, I examine whether the financial crisis disturbed the relationship between these interest rates. Results indicate a strong relation between the Norwegian policy rate and short-term interest rates. This relationship seems to be unaffected by the financial crisis. Further, the relation between the policy rate and long-term interest rates appears to be weaker. Long-term rates seem to rather follow foreign yields.

Key words: Pass-through, Interest rates, Financial markets, Announcements.

JEL classification: G130, G140.

Resumo

O efeito da política monetária nas Taxa de juros

Por Oskar Stavland Hjorth

O efeito da política monetária nas taxas de juros é um tópico tem chamado a atenção dos economistas há longo tempo. O assunto não recebeu menos consideração durante o caos financeiro, que surgiu no final de 2007. A resposta das taxas de juro do mercado monetário a um ajuste da taxa de referência do banco central foi crucial durante a crise financeira. Se a crise financeira perturbou o efeito da política monetária é uma questão central que apareceu no rescaldo da crise. Estudos recentes destacam que para entender o efeito da política monetária é importante excluir as expectativas. As reações da taxa de juro a um ajuste da política monetária, provavelmente serão mitigadas se a mudança de política for corretamente prevista pelo mercado. Ao separar entre a parte esperada e inesperada da taxa de referência da política monetária norueguesa, vou estudar as flutuações diárias em várias taxas de juro noruegueses, antes e depois de um anúncio de taxa de política monetária. Além disso, examino se a crise financeira perturbou a relação entre essas taxas de juros. Os resultados indicam uma forte relação entre a taxa de referência norueguesa e as taxas de juros de curto prazo. Esta relação parece não ser afetada pela crise financeira. Além disso, a relação entre a taxa de referência e as taxas de juro de longo prazo parece ser mais fraca. As taxas de longo prazo parecem seguir as taxas de juro estrangeiras.

Palavras-chave: pass-through, taxas de juros, mercados financeiros, anúncios.

JEL classificação: G130, G140.

Summary

1.A List of Figures

1.B List of tables

1. Introduction

The 20th of August 2016, the largest business newspaper in Norway, «Dagens Næringsliv», published an article concerning how the two most important interest rates were moving in opposite directions. The newspaper was referring to the Norwegian policy interest rate and the most central Norwegian money market rate, Nibor (Norwegian interbank offered rate). The newspaper considered this as a rare event, and remarked that these interest rates had diverged from each other the last year (Takla, 2016).

There is a broad understanding that key policy rates have a strong relationship with the associated short-term interest rates, which further affect the relationship between the policy rate and long-term interest rates. But how strong is this relationship? How do interest rates behave if the policy rate is adjusted?

Roley and Sellon (1995) desired to answer these questions. By observing one-day reactions in the American interest rates, before and after the target federal funds rate[1] announcement, the researchers reported a strong relation between the target federal funds rate and the short-term interest rates. However, the connection between the target funds rate and the longer interest rates rate seemed weak and variable. The economists found this odd. According to the expectation hypothesis the target funds rate ought to affect long-term interest rates, as well as the short-term rates.

However, recent literature appoints answers for the apparent missing link. The efficient market hypothesis suggest that market participants are rational and forward-looking. All available information should therefore be reflected in interest rates, including predicted adjustments in monetary policy. Accordingly, an interest rate which anticipate a larger policy rate in the future is unlikely to react if these predictions are fulfilled. Market expectations can therefore introduce disturbance when the monetary pass-through effect is studied.

In this thesis, I have investigated the pass-through effect from the Norwegian policy rate to other interest rates. By separating between the expected and unexpected portion of a

[1] The policy rate in the U.S.

Norwegian policy rate change, the monetary pass-through effect to Norwegian money market rates, Treasury Bill rates, as well as long-term Bond rates.

Moreover, after the announcement of Lehman Brothers bankruptcy, the already existing tension in the financial markets bloomed into a financial crisis. Since periods with financial instability tend to create fluctuations in interest rates, there are reasons to believe that the relationship between the policy rate and other interest rates was disturbed. Therefore, I have expanded my research by studying whether the pass-through effect was affected by the overshadowing financial chaos during the financial crisis.

My findings suggest a strong and robust policy rate pass-through effect to short-term interest rates. The relationship appears to be unaffected by the financial crisis.

However, the relation between the policy rate and long-term rates seems weaker. One explanation could be an illiquid Norwegian Bond market. Long-term interest rates may be more affected by supply and demand, rather than the policy rate.

The dissertation is separated into 10 sections. Section 2 and 3 briefly describe how Norwegian monetary policy is conducted, before describing necessary interest rate theory. Section 4 revolves around Norwegian interest rates and their markets, before shortly describing the financial crisis and the sovereign debt crisis. In section 5, I review former empirical studies concerning the monetary pass-through effect.

Section 6 explains how the expected and unexpected portion of the policy rate adjustment was obtained. A considerable amount of the work implemented in this thesis is presented here. Therefore, this section is awarded much space.

Section 7 describes the econometrical approach. I continue by presenting the model in section 8, which lead me to the results in section 9. Finally, I conclude.

2. Monetary Policy in Norway

2.1 The Inflation Target

Like many central banks, the central bank of Norway (hereafter «Norges Bank») conduct their monetary policy with a flexible inflation target as a nominal anchor. This means that Norges Bank adjusts the policy rate, aiming to stabilize the annual growth in consumption prices for an approximately 2,5-percent level (hereafter «the Inflation target») (Claussen, Jonassen, Langbraaten, 2007).

The inflation target is flexible, in the sense that the production gap, unemployment and financial stability is not overlooked. Accordingly, a period with high inflation, high demand and lower unemployment, compared to the natural rate[2], creates expectations of higher interest rates. Due to these conditions, Norges Bank has incentives to increase the policy rate to moderate the tension in the economy (Claussen, Jonassen, Langbraaten, 2007).

The above-mentioned policy rate is Norges Bank most powerful instrument in their implementation of monetary policy. The policy rate is known as the Folio interest rate (hereafter «the Folio interest rate» or «the Folio rate»).

2.2 The Folio Interest Rate and Expectations

Normally, the Executive board at Norges Bank determines the Folio rate every sixth week. The Folio rate functions as the interest rate the commercial banks obtain with their deposits with Norges Bank. This is the Folio rate´s main purpose, and is described and acknowledged as the first link in the transmission mechanism in monetary policy[3]. Accordingly, in order to have an efficient monetary policy, it is fundamental that short-term (< 1-year) interest rates follow the Folio interest rate. Moreover, the Folio rate and its impact on short-term interest rates, should further affect agents' expectations, the demand and the exchange rate in Norway (Claussen, Jonassen, Langbraaten, 2007).

---

[2] The natural unemployment rate is defined as the existing unemployment in a healthy economy. Often referred to as the structural unemployment rate (Steigum, 2006, Pp 171-180).

[3] A more detailed description of the transmission mechanism is found in «The inflation targeting framework in Norway» (Soikkeli, 2002).

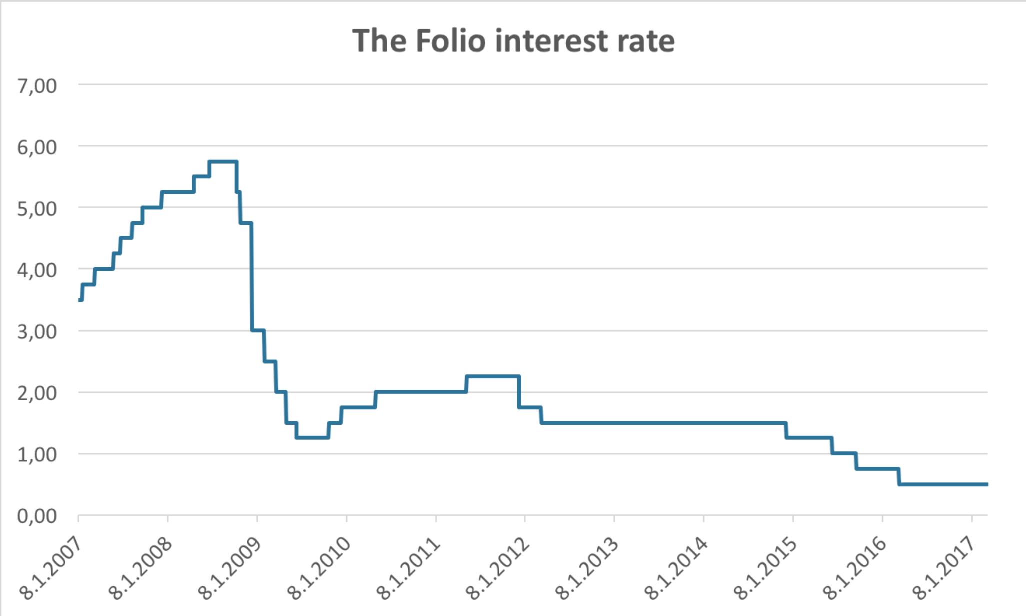


Figure 1: The development of the Folio interest rate between 2007-2017. Monthly average. In percent. Data source: Norges Bank

Expectations are therefore an important factor in the implementation of monetary policy. For Norges Bank it is important to display independency, transparency and commitment in order to shape monetary expectations. The importance of these factors was highlighted by Kydland and Prescott (1977) with their Nobel winning paper «Rules, rather than discretion: The inconsistency of optimal plans» (Claussen, Jonassen, Langbraaten, 2007).

Accordingly, by committing to the Inflation target, and conducting monetary policy without interference from politics, Norges Bank can create trustworthy expectations concerning their monetary decisions. Consequently, the effect of monetary policy and Norges Bank's decisions do not only affect the spot Folio rate, but also the expectations concerning the future path for the monetary policy (Claussen, Jonassen, Langbraaten, 2007). The central bank´s ability to create expectations, due to independency and commitment, is also emphasizes by Woodford:

«*The effectiveness of changes in central-bank targets for overnight rates in affecting spending decisions (and hence ultimately pricing and employment decisions) is wholly dependent upon the impact of such actions upon other financial-market prices, such as longer-term interest rates, equity prices, and exchange rates […] Thus the ability of central banks to influence expenditure, and hence pricing, decisions is critically dependent upon their ability to* *influence market expectations regarding the future path of overnight interest rates, and not merely their current level.»* (Woodford, 2003, Pp. 16).

2.3 Controlling Interest Rates - Norges Bank's Liquidity Management

As mentioned in section 1.2, short-term interest rates must follow the Folio interest rate, in order for the monetary policy to be effective.

The main objective with Norges Bank's liquidity management is to keep the overnight rate in the interbank market (known as the NOWA[4] interest rate) as close to the Folio rate as possible. To accomplish the objective, Norges Bank has set the terms for the bank system. In addition, appropriate market operations are implemented (Kran and Øwre, 2001).

Similar to private individuals having deposit accounts in banks, Norwegian banks have deposit accounts with Norges bank. The sum of all these commercial bank accounts constitutes the bank's reserves (hereafter «Reserves»). Reserves are the only approved mean of payment between banks. The amount of Reserves, prior to market operations implemented by Norges Bank, is known as the structural liquidity (hereafter «Structural liquidity») (Aamodt and Tafjord, 2013).

When a customer of bank X transfer 100 Norwegian kroner[5] (hereafter «NOK») to a customer of bank Y, these 100 NOK are transferred between the banks' accounts in Norges Bank. Hence, the distribution of the Reserves in the banking system changes constantly. However, the total amount of Reserves remains constant. The bank system is a closed system. No banks, except Norges Bank, can influence the total amount of Structural liquidity in the bank system (Aamodt and Tafjord, 2013) (Syrstad, 2011).

However, there is another component, beyond Norges Bank control, which can alter the Structural liquidity. Equivalent to Norwegian banks the Norwegian Government also have a deposit account in Norges Bank. Due to large deposit and payment activity, the Government's

[4] Norwegian Overnight Weighted Average (NOWA) is the interest rate determined by demand and supply between commercial banks in the interbank market from today to tomorrow. The NOWA rate is explained more in detail section 4.4.

[5] The official currency of Norway.

account represents the main component for fluctuations in the structural liquidity. Tax income and issuing Government Treasuries are measures, which manoeuvre liquidity from commercial bank deposits to the Government's account with Norges Bank. Consequently, the amount of reserves is reduced. On the contrary; public wages, child support and other welfare benefits are all public expenditures, which move liquidity from the Government's account to commercial banks deposits with Norges Bank. Such public transactions expand the total amount of the structural liquidity. Therefore, autonomous movements in the Government deposits are the primary reason for the variation in the Structural liquid (Kran and Øwre, 2001).

Market operations are implemented by Norges Bank to oppose shortage or excess liquidity in Structural liquidity. These operations are primarily conducted through F-loans and F-deposits. F-loans are supplied through American/multi-price auctions. Norges Bank establishes the total amount of liquidity, which is available through F-loans. Correspondingly, commercial banks submit bids with a desired amount of loan associated with a submitted interest rate. This interest rates must be equal or greater, compared to the current Folio rate. Those commercial banks who have submitted bids within Norges Bank established total amount of liquidity are granted the F-loan with their proposed interest rate. The allotment is ranked such that the bids with the highest submitted interest rates receive loans first. Banks obtain F-loans until the established amounts of liquidity is reached. All loans are granted against collateral in securities (Norges Bank, 2011).

The same principle applies to the F-deposits. However, the desired interest rate must now be equal or lower to the current Folio rate. Interest rates submitted for both the F-loans and the F-deposits have a 1 to 1 relationship with the Folio rate. This means that an adjustment in the Folio rate is followed by an alteration in both the granted deposit and lending rate (Norges Bank, 2011).

Hence, with market operations, Norges Bank can regulate the structural liquidity in the closed bank system. However, Norges Bank attempt to maintain the Structural liquidity within 4-12 NOK billion every day (Kran and Øwre, 2001). The surplus of Reserves, combined with Norges Bank standing facilities are the main components in achieving a close relationship between the Folio interest rate and the NOWA rate in the interbank market.

2.4 Standing Facilities, The Interest Rate Corridor and The Quota System

Norges Bank's standing deposit facility offer deposit accounts to banks (the Reserves). Commercial banks can deposit Reserves with these accounts, receiving the Folio interest rate. However, only a limited amount of the Reserves obtains the Folio interest rate. Reserves which exceeds the quota acquire the "reserve rate". The reserve rate shares a one-to-one relationship with the Folio rate and is always 1 percentage point below the Folio rate. Accordingly, banks with a surplus of Reserves, which exceed the quota, have incentives to lend liquidity to banks with a Reserve deficit. I.e. banks with additionally Reserves seek greater interest rates returns, compared to the reserve rate given by Norges Bank (Syrstad, 2011).

Norges Bank's standing lending facility offer banks additionally reserves. During a business day, commercial banks can lend unlimited reserves, absent for interest costs, against collateral in securities. However, if a bank fails to repay the D-loan by the end of the same day, interest costs automatically commence. This interest rate is known as the "D-interest rate" or the "Overnight lending rate". The D-rate also have a one-to-one relationship with the Folio rate. However, in contrast to the reserve rate, the D-rate is always 1 percentage point above the current Folio rate. Therefore, banks with a Reserve deficit have incentives to lend liquidity from other banks to a less expensive interest rate costs, compared to the overnight lending rate offered by Norges Bank (Syrstad, 2011).

Hence, by reassuring a Reserve surplus in the bank system, combined with the standing facilities, Norges Bank create an interest rate corridor. The reserve rate represents the floor of the corridor, the Folio rate operates as the centrepiece, while the D-rate serves as the ceiling. Due to the interest rate corridor and an assured liquidity surplus, the NOWA rate tend to fluctuate strictly around the Folio rate, as presented in the figure 2 (Syrstad, 2011).

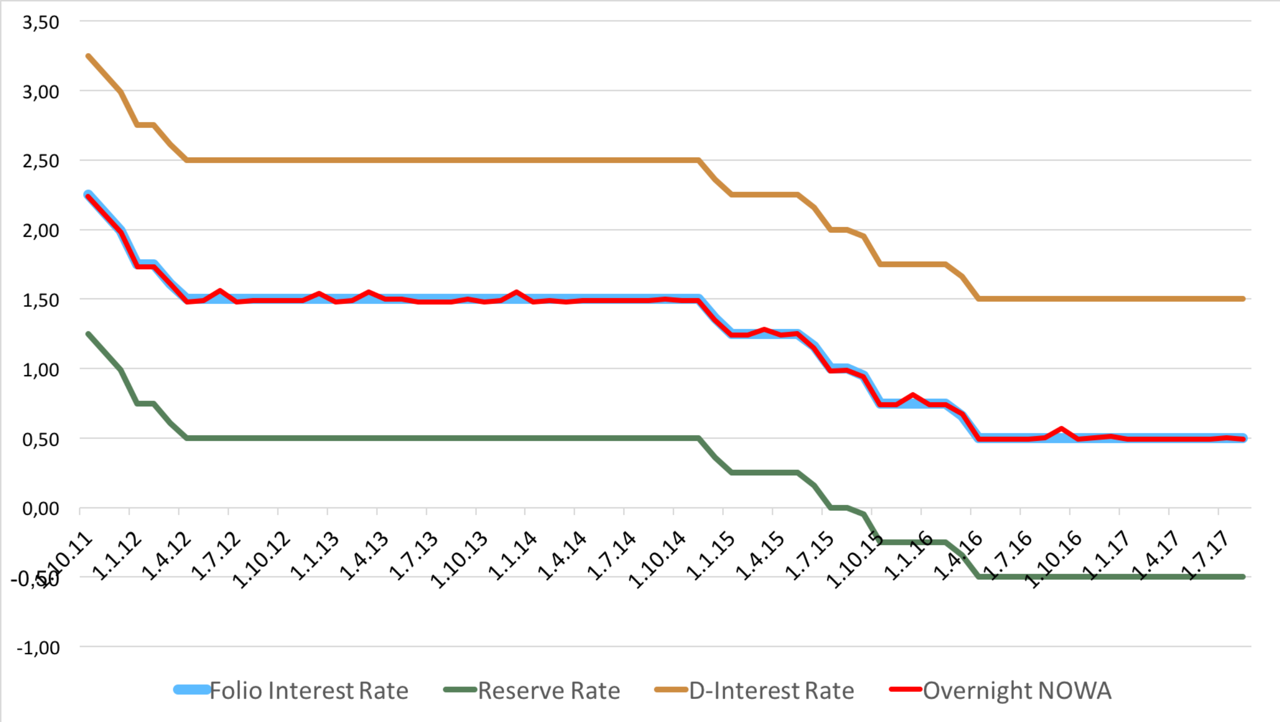


Figure 2: The Interest Rate Corridor between 20011 – 2017. Monthly average. In percent. Data source: Norges Bank

3. Interest Rate Theory

Since my thesis concerns diverse interest rates, I have chosen to include fundamental interest rate theories in this section. This will contribute to an easier understanding throughout this dissertation.

3.1 The Yield Curve

As mentioned in section 1.2, Norges Bank is able to shape expectations concerning forthcoming interest rates. The path of these expected future interest rates is translated into the «term structure of interest rates» or the «yield curve». Economic information and news are factors which affect Norges Bank Folio rate decision, and therefore information and news contribute to shape the yield curve of various financial instruments (Myklebust, 2005). Due to the information contained in the yield curve, the central bank observes different yield curves with great interest (Valseth, 2003).

Concave yield curves – with a positive slope, exhibit interest rates which are anticipated to increase in the future (Figure 3, up and to the left), while a convex yield curve – with a negative slope (Figure 3, down and to the left) reflect interest rates which are expected to decrease through time. Horizontal and linear curves display interest rates, which are anticipated to remain constant (Figure 3, up and to the right). Yield curves can also exhibit a humped curve (Figure 3, down and to the right). Consequently, the yield curve describes the expected development in interest rates for different maturities (Bernhardsen, 2011, Pp 3)

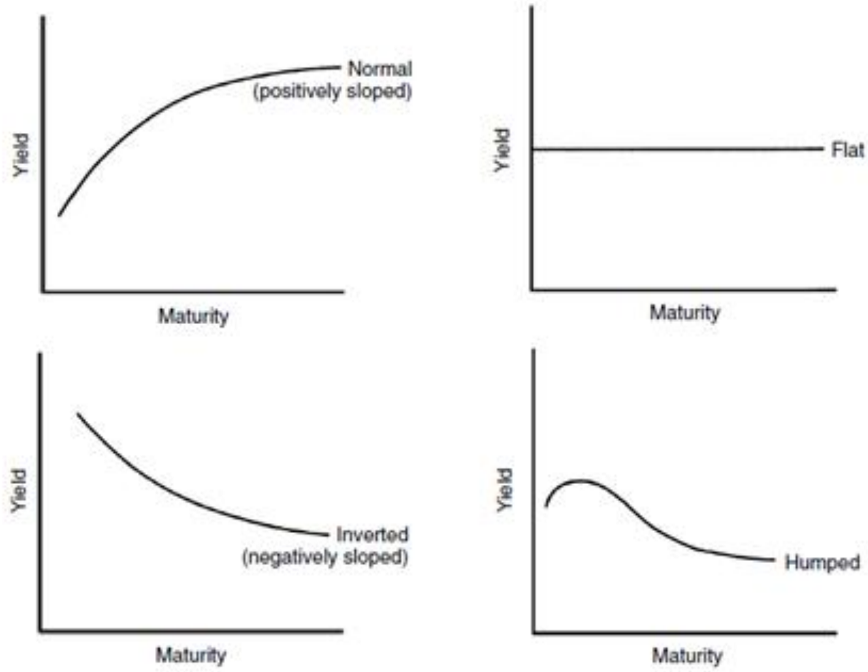


Figure 3: Different yield curves. Figure source: Sonigara, 2012

The yield curve literature is immense, and new contributions regarding the subject seems to be independent of the economic situation. There are however two hypotheses that have received more attention in academia, compared to others (Fung and Chapple, 1994).

3.2 The Expectation Hypothesis

Irving Fisher (1930) and Lutz (1940-1941) have been awarded the recognition for the expectation hypothesis. The hypothesis is based on the absence of arbitrage possibilities (Jarrow, 1981). The theory describes risk neutral agents, which seek to maximize returns. These agents are indifferent regarding maturity and the placement of their capital.

Accordingly, for the market to be absent for arbitrage opportunities, the long-term interest rates must be an average of the spot short-term rates and the expected spot rates in the future. Otherwise, agents can obtain long-term loans and re-invest in shorter instruments with higher interest returns and therefore gain profit, alternatively, raise a short-term loan and re-invest in a long-term security, which provide greater interest returns, compared to the cost of the short-term loan. In both these events, arbitrage is present (Kloster, 2000).

Under the assumption that the expectation hypothesis holds, Bernhardsen demonstrates that implicit interest rates must be equivalent to expected interest rates (Bernhardsen, 2011, Pp. 2-3): An investor wishes to place liquidity for a two-year period. The investor can either choose (1) a two-year maturity placement, or (2) a one-year maturity placement and then re-invest in another one-year maturity. The interest rate that equals these two different investment strategies is the implicit one-year interest rate, in one year. Due to the implicit interest rate, the returns are equal to each other, regardless the strategy chosen. Thus:

$$(1 + i_{2year})^2 = \left(1 + i_{1year}\right)(1 + i^*_{1year\ in\ 1\ year}) \tag{1}$$

Where $i^*_{1year\ in\ 1\ year}$ is the implicit one-year rate, in one year. The one-year (i_{1year}) and two-year (i_{2year}) interest rates are listed in the market. We solve for implicit interest rates[6]:

$$i^*_{1tear\ in\ 1\ year} \approx 2i_{2year} - i_{1year} \tag{2}$$

Any deviations from anticipated one-year interest rate in one year and implicit interest rate create arbitrage possibilities. In the absence of arbitrage, the shape of the yield curve illustrates market participants' expectations regarding the interest rate's development (Bernhardsen, 2011). Hence:

$$i^*_{1year\ in\ 1\ year} = i^e_{1year\ in\ 1\ year} \tag{3}$$

Where superscript e stands for expected interest rate, we insert (3) into (2) and get:

$$i_{2years} = \frac{1}{2}\left(i_{\ 1year} + i^e_{1year\ in\ 1\ year}\right) \tag{4}$$

[6] We apply logs in (1) on both sides, since $\ln(1 + i_t) \approx i_t$, we obtain (2).

Therefore, according to the expectation hypothesis, an investment has equal returns regardless of the maturity. Correspondingly, the hypothesis asserts that securities with various maturities are perfect substitutes, because the yield returns must be equal (Jarrow, 1981).

3.3 Liquidity Preference Hypothesis

Hick (1946) and his “Liquidity preference hypothesis” reject the notion of agents being indifferent concerning the maturity. Agents are rather risk averse. Accordingly, an agent consider money or a short-term investment as more liquid and therefore prefer to hold financial assets with a shorter maturity. Long-term securities are more exposed to interest rate fluctuations and therefore evaluated as a riskier investment. Hence, Hick therefore suggest that securities with different maturities as imperfect substitutes (Jarrow, 1981).

In order to make longer maturities attractive to a risk averse agent, a maturity-premium most be implemented to the interest rate. Accordingly, the agent is being compensated with a premium due to the uncertainty of holding the more exposed long–term asset. Consequently, the level of compensation expands along with the duration of the maturity. Normally, there is a positive relationship between the maturity and the maturity premium. Similar to the expectation hypothesis, the liquidity preference theory states that the yield curves consist of the average between the current spot interest rates and the expected interest rates, but in addition a maturity premium must exist (Kloster, 2000).

There have been a large number of studies investigating both the liquidity and the expectation hypothesis. The majority of these studies dismiss that that prices of interest rates are precise instruments to predict the future, at least for longer maturities. Thus, prices on interest rates must consist of more than only expectations and a maturity premium (Kloster, 2000).

3.4 Premiums

The market works as a good information source, and how different markets rates are priced seems to reflect expectations for economic development. However, market participants are not always fully informed and are therefore exposed when holding a financial instrument. Consequently, different premiums exist as a compensation for market participants that are willing to take this risk (Valseth, 2003)

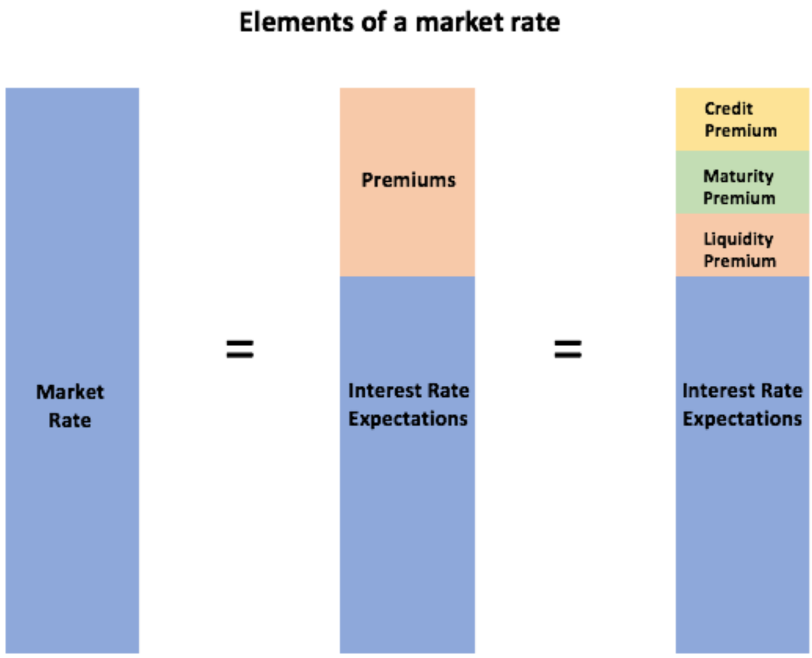


Figure 4: The content of a market rate (Valseth, 2003)

3.5 Maturity Premium

If the maturity of a financial asset does not match the investor's preferred invest-horizon, the investor can require compensation. This compensation is known as a maturity or term premium. Due to a longer duration, long-term assets are more exposed to unfavourable interest rate fluctuations. Long-term financial assets therefore introduce more risk, compared to a short-term instrument. The maturity premium can be even greater if there exists uncertainty evolving in the yield curve of the financial instrument. Accordingly, investors demand higher yield returns if the maturity of the instrument do not correspond to their preferred investment interval (Valseth, 2003).

3.6 Credit Premium

The credit or risk premium is a compensation to agents who are willing to hold an instrument which is evaluated with a higher probability to default. Accordingly, the magnitude of the credit premium depends on the counterparty. If the counterparty is considered less creditable, the credit premium is likely to increase. These premiums tend to vary across different interest rates: A market rate will usually have a larger credit premium, compared to a Bond issued by a State, since Governments typically are weighted as considerably more creditable, compared to firms. Yet, the creditworthiness[7] of the issuer, regardless of being a state or company, is the component which ultimately determines the size of the premium. Hence, a riskier investment, generally displays a higher interest rate to a comparable investment, which is considered less risky (Valseth, 2003).

3.7 Liquidity Premiums

The liquidity premium is a compensation for holding an asset, which is considered illiquid. These premiums can arise in smaller markets where the frequency of turnovers is less, compared to other markets. Therefore, the purchasing price and sales price of illiquid assets are more exposed to variations, caused by the demand and the supply for these securities. Accordingly, agents consider holding illiquid securities riskier, since they potentially can be more difficult to sell. Generally, illiquid instruments are considered to display higher interest rates, compared to other comparable instruments, which are less liquid (Valseth, 2003).

4. Norwegian Interest Rates and Their Markets

In this section I will describe Norwegian interest rates and their market characteristics. I have chosen to differentiate between short-term and long-term interest rates. Short-term interest rates are often referred to as «money market rates». The money market consists of different markets where financial participants can either demand or supply liquidity. The common denominator for these markets are maturities within a year. Long-term interest rates are often known as interest rates on Bonds with maturities exceeding one year.

4.1 The Swap Markets

An interest rate swap contract is a settlement between two parts where one part prefers a fixed interest cost («The swap rate»), while the counterpart accept the floating interest cost. The swap rate is calculated such that the contract is worthless when it is established. This means that the costs generated by the fixed rate should be equal to the anticipated term structure of the floating interest rate costs, given the maturity of the contract. The floating rate therefore functions as the underlying instrument in the contract. Correspondingly, the value of the

[7] There are several credit rating agencies, such as the Fitch Group, Standard & Poor's and Moody's (European Securities and Markets Authority, 2015).

contract depends on the expected development in the underlying instrument (Rakkestad and Hein, 2004).

The intuition is best illustrated by an example (Bernhardsen, 2011): Agent A and agent B appoint an amount («principal») for a given time period, in this example, 3 years. The principal is never exchanged between the parties, but determines the cash flow of the two different interest rate expenditures (Rakkestad and Hein, 2004). Both parts have agreed that agent A should pay a fixed interest rate, the swap rate, to agent B. Hence, agent A should pay agent B:

$$(1 + i_{Swap\ 3years})^3 \tag{5}$$

Moreover, both parties have agreed that agent B should pay the annual spot rate to agent A. The spot rate is naturally formed by the market. However, the rates in one and two years are unknown, agent B should therefore pay agent A:

$$(1 + i_0)(1 + i_1)(1 + i_2) \tag{6}$$

Where i_0 is the current interest rates, i_1 and i_2 are the unknown rates, respectively for one and two years in the future.

After the 3-year period these interest rates are listed in the market, and the amount that agent B owns agent A is a known amount. If the annual floating spot rate over the three years is less, compared to the fixed 3-year swap rate, agent B has gained the difference between the two interest payments. In this case, the floating rate has deviated from initial market expectations associated to the underlying instrument.

Since the principal never is exchange, the only risk associated with swap agreements is the payment settlement involving the difference between the two rates (Bernhardsen, 2011). Swap agreements are therefore generally associated with a minor credit premium.

The swap market is a segment of the derivative market, hence a non-asset market. Therefore, the price of these rates is less affected by supply and demand. Bonds, on the other hand, are often issued in limited quantities and therefore more exposed to price variation due to the demand and the supply. However, a high demand for swap contracts might indicate that agents consider the swap rate as profitable. Thus, the swap rate is expected to give higher returns in the future, compared to the exchanged and floating market rate. The equilibrium in a swap market is therefore determined by the available information and market expectations concerning the underlying instrument (Rakkestad and Hein, 2004).

In Norway, normally the 3-month and 6-month Nibor rate[8] is applied as the underlying variable in a swap rate contract. (Rakkestad and Hein, 2004).

4.2 The Interbank Market

The interbank market is a part of the money market. In the Norwegian interbank market, banks can supply or demand reserves without collateral, as stated in section 2.4. Some banks are usually in a deficit position at the end of a business day. These banks can inquire loans from banks which have a surplus of reserves. Accordingly, the interbank market works as a safety net in order to comply with the liquidity terms imposed by Norges Bank. Interbank rates with longer maturities are rarely traded. However, money market rates with longer maturities serve as reference rates for different financial contracts and are therefore important (Bernhardsen, Kloster and Syrstad, 2012).

4.3 The Overnight Interest Rates

Norwegian overnight weighted average (hereafter «Nowa») is the interest rate with the shortest maturity in the interbank market. Nowa is the average of the overnight interest rate. This rate is determined by the demand and supply for reserves among banks, from one day to the next. Due to numerous of daily transactions, consistently accessible liquidity is a necessity for banks. Consequently, there is considerable activity for the shortest maturities in the non-collateral interbank market. As stated in section 2.4, due to Norges Bank's liquidity management, overnight rates tend to be approximately at the same level as the Folio rate (Bernhardsen, Kloster and Syrstad, 2012).

[8] A closer description of the Nibor rate is found in section 4.5

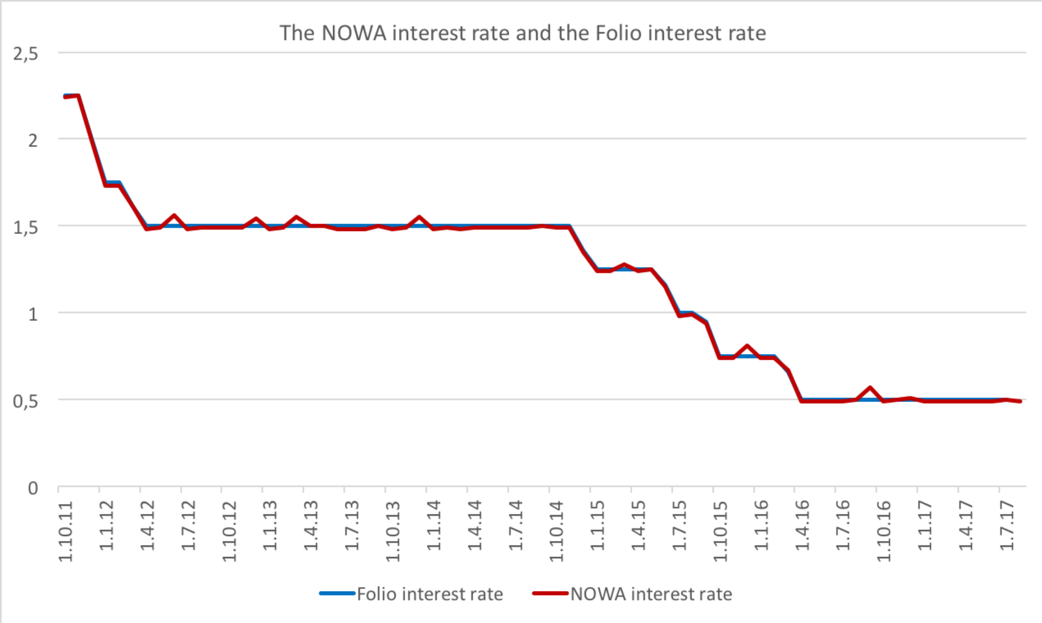


Figure 5: Covariation between the Nowa and the Folio rate between 20011 - 2017. In Percent. A Monthly average. Data source: Norges Bank

4.4 The Nibor Interest Rate

The Nibor rate is the main Norwegian interbank interest rate. Like the Nowa rate, the Nibor rate reflects the average interest rate demanded and supplied by banks. The disparity between the Nowa rate and the Nibor rate is found in the maturity and the frequency of turnovers.

While Nowa is frequently traded and reflects the average interest rate costs for loans in the interbank market from one day to the next, the Nibor rate is quoted with maturities of 1 week and 1, 2, 3, 6, 9 and 12 months. Furthermore, the Nibor rate is rarely traded. Nibor is determined by a panel of banks, consisting of the six largest commercial banks in Norway.[9] Hence, Nibor is quoted on the basis of what the Nibor panel *would* demand for interest compensation for lending NOK, given the maturity (Lund, Tafjord and Øwrejhnsen, 2016).

[9] The Nibor panel: DNB Bank, Danske Bank, Handelsbanken, Nordea, SEB and Swedbank (Lund, Tafjord and Øwrejhnsen, 2016).

Nevertheless, the Nibor rate is used as a reference rate for several different financial contracts. Especially the 3-month Nibor receives notable attention, being an indicator for the Norwegian economic development.
The foundation of the Nibor rate is the expected average Folio rate with an additional premium, given the maturity. Hence:

$$(1)\ i = EF + RP\ , \tag{7}$$

Where i express the Nibor rate, EF is the average expected Folio rate given the maturity. RP is the premium and exhibit the difference between the Nibor rate and the expected Folio rate.

$$RP = i - EF\ , \tag{8}$$

The Nibor rate is heterogeneous, compared to other reference rates.[10] Because the demand for NOK loans with maturities is small, the Nibor rate is constructed as an exchange swap rate. This means that the Nibor panel quote the Nibor rate based on an American dollar (hereafter «USD») rate. This rate reflects the price for lending USD without collateral in the money market. The demand for USD dominate the demand for NOK. Accordingly, the Nibor panel therefore quote the Nibor rate easier (Lund, Tafjord and Øwrejhnsen, 2016).

The exchange rate[11] must therefore be implemented in the dollar interest rate. Ceteris paribus, if the NOK appreciate against the USD, the Nibor rate is likely to decline. On the contrary, a depreciating NOK, relative to the USD, can contribute to a relative larger Nibor rate. The reason is that 1 USD is relatively more expensive with NOK as means of exchange. Therefore, both the exchange rate and the money market USD interest rate are components which directly can affect the Nibor rate (Lund, Tafjord and Øwrejhnsen, 2016).

During "normal" financial times, the Nibor rate reflects the expected Folio rate, since low financial stress tends to decrease potential premiums. However, a turbulent economic environment can amplify various of premiums. Thus, the Nibor is likely to increase and simultaneously diverge away from expectations regarding the Folio rate. The risk premium is therefore supervised closely by Norges Bank, as it can disturb the transmission mechanism and mitigate the monetary policy effectiveness (Lund, Tafjord and Øwrejhnsen, 2016).

[10] Reference rates exist in many economies, to mention a few; Sweden (Stibor), England (Libor) and the Euro area (Euribor) (Lund, Tafjord and Øwrejhnsen, 2016).
[11] The amount of Norwegian Kroner per U.S. dollar ($\frac{USD}{NOK}$)

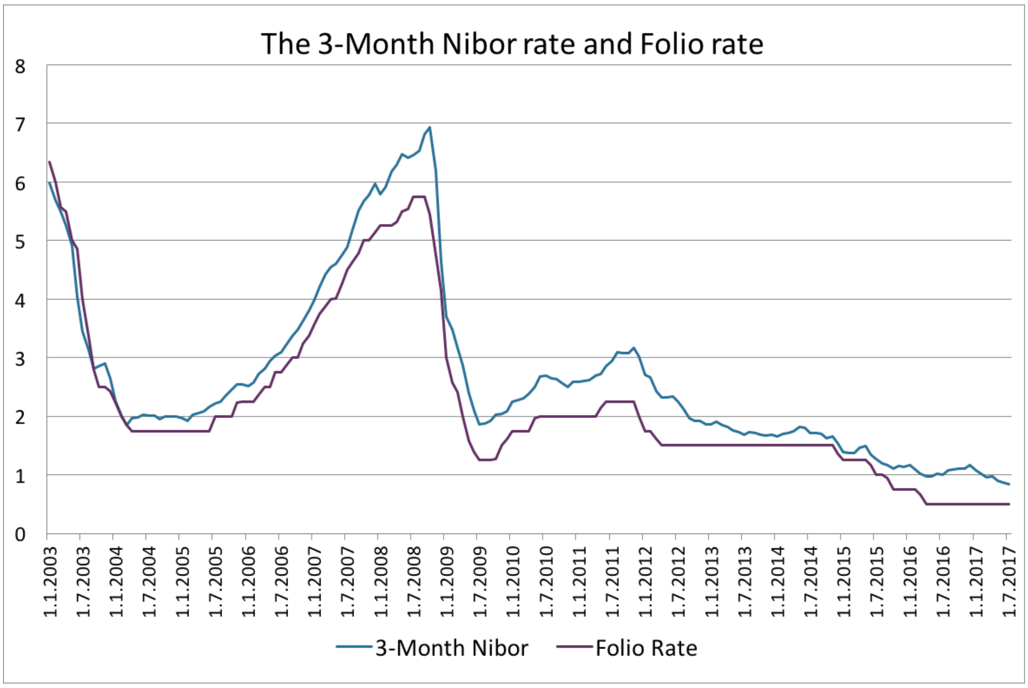


Figure 6: The 3-month Nibor rate with the Folio rate between 2003 - 2017. Monthly average. In percent. Data source: Norges Bank

4.5 Norwegian Treasury Bills

A Treasury Bill is a short-term debt security issued by the Government. The issuer is often a state, which need funding for larger projects. Norwegian Government Treasuries are issued by the Government, with maturities ranging from 3 to 12 months. All Treasuries are issued in NOK and quoted at Oslo stock exchange (Evjen, Grønvold, Gundersen, 2017).

These bills are organized as zero-coupon bills. This means that the Government are not paying any interest costs to the investor who is holding the bill. Hence, the par value[12] («face value») determines the interest rate, combined with the market value and the maturity (Bernhardsen, 2011).[13]

The general interest rate level is the main influencer regarding the treasury's market value and therefore its interest rate (Figure 6). A Treasury issued with a par value of 100 NOK and present market value of 90 NOK, provide an interest rate of 10 percent. For simplicity, let us

[12] The initial price of the bond when issued.

[13] A more detailed description of the interest rate formation of the Treasury Bill is found in Bernhardsen's paper: «Renteanalysen» from 2011

assume that the general interest rate level also is at 10 percent level. If interest rates increase to 15 percent, the Treasury appear to be an unattractive financial object. Buyers therefore demand a compensation in form of a lower Treasury price. In order to compete with other investment opportunities, the market price of the Treasury must consequently decrease. Non-existing demand therefore force the market price to decline until it reaches approximately 87 NOK, giving 15 percent in return, equivalent to the general interest level. Accordingly, the price declines, until the Treasury rate corresponds to the present interest rate environment (Norges Bank, 2004).

Therefore, the Government Treasury rates are often used to reflect Folio rate expectations, with an additional maturity and liquidity premium.

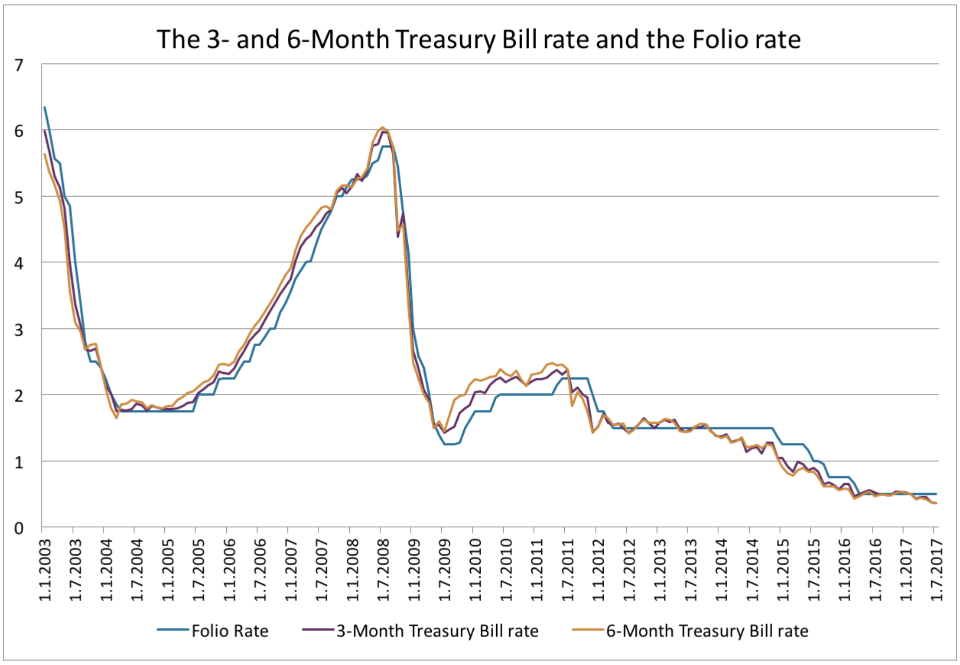


Figure 7: The 3- and 6-month Norwegian Treasury bill rate with the Folio rate between 2003 - 2017. Monthly average. In percent. Data source: Norges Bank

Norway's «Government Pension Fund Global», often called the petroleum fund, is the main reason for Norway's unusual economic position. Norway do not have fiscal deficits. The Government issues Bonds or Treasuries mainly to finance varies of public institutions. Therefore, relative to other comparable countries, the Norwegian Government issues a minority of Bonds and Treasuries (Figure 7). The disadvantage with few issued Treasuries is illiquid Treasury markets. As mentioned in section 3.8, market participants require liquidity premiums as a compensation for holding an illiquid security. However, there has been an improvement in the liquidity in the Treasury market recent years. While the amount of outstanding Government Treasury Bills was NOK 28 billion in 2000, there was registered NOK 76 billion in 2016 (Oslo Stock exchange, 2017).

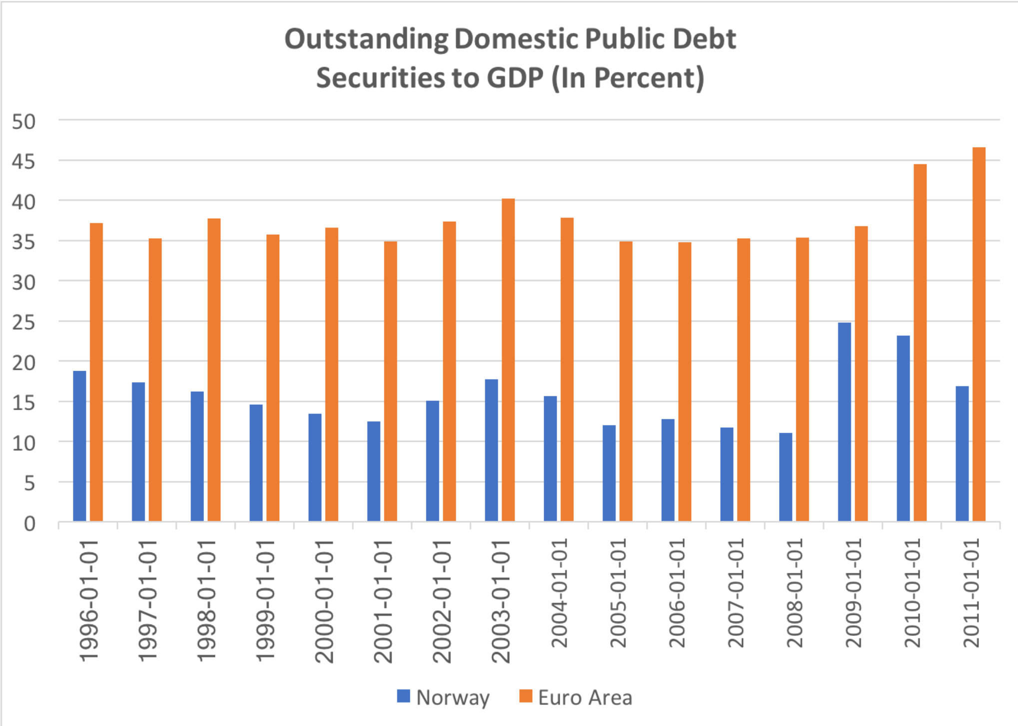


Figure 8: Outstanding domestic public debt in securities[14] relative to GDP. Annual data. In Percent. Data source: Federal Reserve Bank of St. Louise

The risk associated with the security is often credit rated. The credit rank of a Treasury Bill is likely to affect the credit premium. Poor rated Bonds or Treasuries are evaluated to carry higher risk of default. Correspondingly, the credit premium pushes the price down. However, agents who tolerate the risk are normally awarded with higher yield returns.

The Government possess an ownership in the Norwegian oil fund. This ownership is a possible contributor to why Norwegian Treasuries have obtained AAA credit rating by the

[14] The designation “security” contains all securities, including Treasuries and Bonds.

most acknowledged credit rating agencies. [15] Thus, Norwegian Treasuries are considered to be absent of any credit premiums (Evjen, Grønvold, Gundersen, 2017).

4.6 Long-term Interest Rates - The Government Bond

Long-term interest rates are often a vague term for government Bonds with a par value and maturities exceeding 1 year. Investors holding the Norwegian Government Bond receive an annual coupon. This means that the Norwegian government, once a year, pay interest rate costs to the investor holding the Bond. The annual coupon and the duration of the maturity are the main differences between Treasuries and Bonds.

In the Norwegian Bond market, maturities within 2 -10 years are the most traded. All Bonds are issued in NOK and quoted at Oslo stock exchange (Bernhardsen, 2011).

The Bond's market value is affected by the general interest rate environment. However, more important are expectations regarding the future interest rates, future inflation level and premiums (Bernhardsen, 2011). Figure 8 display variation in the 5- and 10-year Bond in conjunction with the Folio rate.

[15] Rated AAA by; Fitch ratings, Moody's and S&P global ratings the last 30 years (Tradingeconomics.com, 2017)

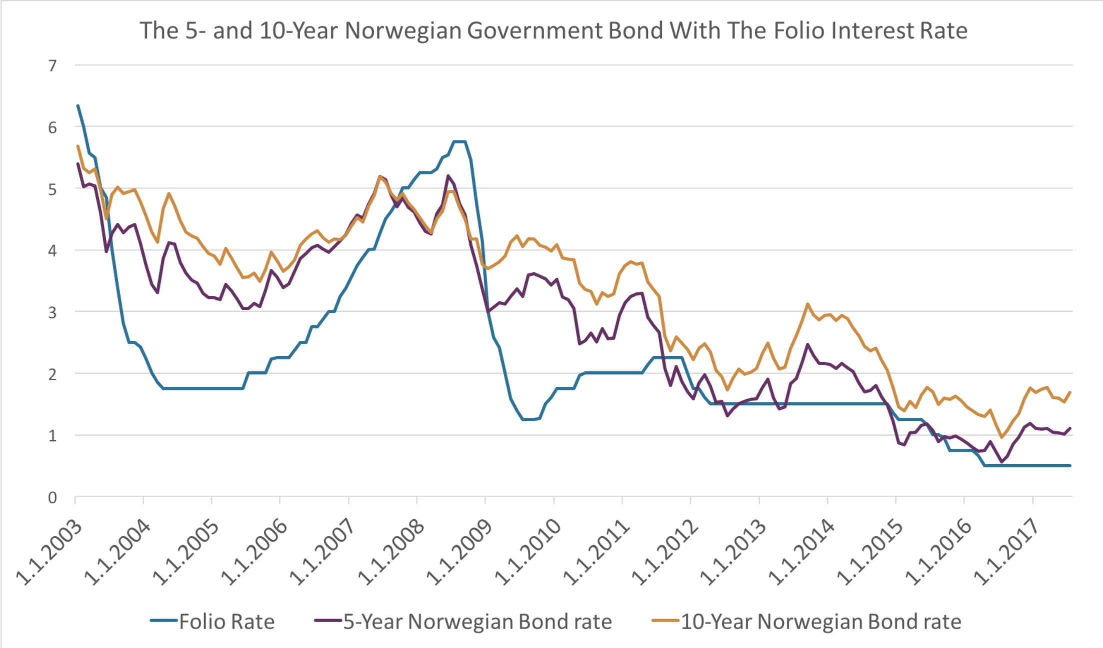


Figure 9: The 5- and 10-year Norwegian Bond rate with the Folio rate between 2003 - 2017. Monthly average. In percent. (Data source: Norges Bank)

Due to reasons mention in section 4.6, Norwegian Government Bonds are rated as among most secure Bonds in the world. Like the treasury, Norwegian Bonds are unlikely to contain credit premiums (Evjen, Grønvold, Gundersen, 2017).

Furthermore, the Bond market in Norway is acknowledged as illiquid. However, the frequency of turnovers is higher in the Bond market, compared to the Treasury market (Bernhardsen, 2011). The number of turnovers equalled NOK 291 billion in 2012, while in 2016 there was registered NOK 407 billion worth of turnovers. This resulted in an average daily turnover of NOK 1,6 billion. Accordingly, there have been improvements in the liquidity in the Bond market recently, which is also evident in figure 9 (Evjen, Grønvold, Gundersen, 2017).

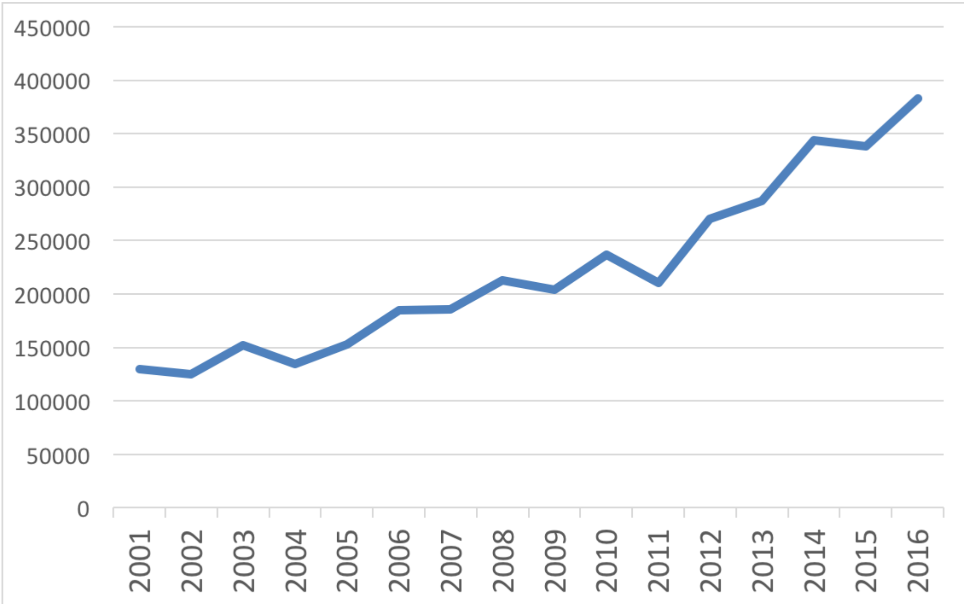


Figure 10: Outstanding Government Bonds. NOK millions. Annual data.
Data source: Oslo stock exchange.

4.7 The Financial Crisis and Unconventional Market Operations

The financial crisis is a central occurrence in my research. I therefore find it expedient to briefly describe the crisis, and the unusual market operations which were conducted by Norges Bank and the Norwegian Government, in order to meet the difficulties which arose due to the crisis. Finally, the Sovereign debt crisis is mentioned.

The beginning of 21th century was dominated by a cyclical upturn in the U.S. The period was dominated by low interest rates, increasing house prices and small premiums in the financial markets. However, during 2007 the financial instability surfaced, mostly due to questionable solidity of banks. As interest rates in the United States began to increase, house prices started to decline. American securities, which consisted of mortgage portfolios, were held by many banks in various of countries. A vast portion of these mortgages are known as «subprime loans». The name «subprime» arose as many of these borrowers were granted mortgages, which they could not pay. Simultaneously, as interest rates increased, subprime loans began to default. Since several banks were exposed to these American securities, the global financial market experienced a loss of confidence (Haare, Lund and Solheim, 2014).

The international financial instability reached its peak the 15th of September 2008, when the investment bank Lehman brothers declared bankruptcy. The credit premiums flourished. Banks refused to lend liquidity. The result was rapidly increasing money market rates. The initial financial uncertainty was developing into a financial crisis (Haare, Lund and Solheim, 2014).

The Norwegian money market was highly affected by the financial crisis. The Nibor and Norwegian Treasury rates fluctuated heavily, while Norges Bank swiftly decreased the Folio rate. As cited in section 3.5, the Nibor rate is constructed as a swap rate (swapped with the USD). Hence, with increasingly premiums in the dollar market and shortage of USD supply, Norwegian banks experienced difficulties quoting the Nibor rate. Norges Bank recognized the pressure in the interbank market and supplied the market with additional NOK and USD with incentives to control the market interest rates (Haare, Lund and Solheim, 2014).

In spite of extraordinary supply of both NOK and USD, the spread increased between Norwegian money market rates and the Folio rate. Norges Bank evaluated the situation as critical. Therefore, unconventional measures were applied. Norges Bank established a swap agreement between the Norwegian Government and Norwegian banks. Norwegian commercial banks were given the possibility to exchange covered Bond, consisting of Norwegian mortgages, against Norwegian Treasuries. As stated in section 4.6, Norwegian Treasuries are rated AAA, they are therefore evaluated as highly trustworthy. With newly issued Treasuries in their balance sheets, Norwegian banks obtained liquidity easier both abroad and domestically (Haare, Lund and Solheim, 2014).

While Norges Bank established the swap-agreement, the demand for Treasuries amplified, due to the domination of the premium in the Nibor rate. Urgent demand for Treasuries and Bonds, combined with illiquid markets, forced the prices upwards. Accordingly, the interest rate for Treasuries began to decrease. The improved demand for Norwegian Treasuries and the assumed premiums in the Nibor rate is evident in figure 9 (Haare, Lund and Solheim, 2014).

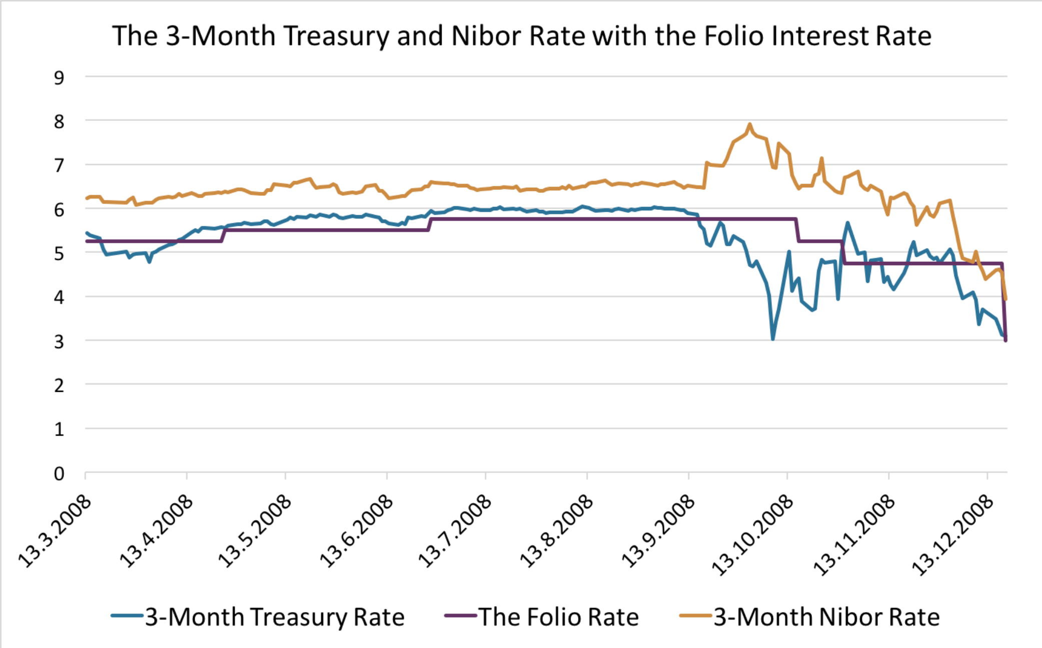


Figure 11: The 3-Month Treasury and Nibor rate with the Folio interest rate from 13.03.2008 – 13.12.2008. Daily data. In percent. (Data source: Norges Bank)

Finally, the swap-agreement was adopted by the Norwegian parliament 24th of October 2008. The first auction took place the 24th of November 2008. The swap-agreement were restricted to a maximum of NOK 350 billion newly issued Treasuries and Bonds. However, the demand declined after issuing Treasuries and Bonds equivalent to NOK 240 billion. The final swap-agreement was conducted 19th of October 2009 (Haare, Lund and Solheim, 2014).

4.8 The Sovereign European Debt Crisis

After the financial crisis, the Sovereign European debt followed. The debt crisis was triggered when uncertainty arose regarding Greece's solvency. The financial stress spread out to several European countries. Especially countries like Greece, Portugal, Ireland, Spain and Italy was most hardly affected by the thriving uncertainty. Accordingly, the credit premiums in the above-mentioned Bonds increased rapidly, which was followed by lacking demand. During the spring 2010 was the «European Financial Stability Mechanism» adopted with incentives to help those countries, which suffered the most (Natvik and Sauvik, 2013). The Sovereign European debt crisis had less of an impact on the Norwegian economy, compared to the financial crisis. This is evident when observing the annual change in Norway's GDP in figure 10.

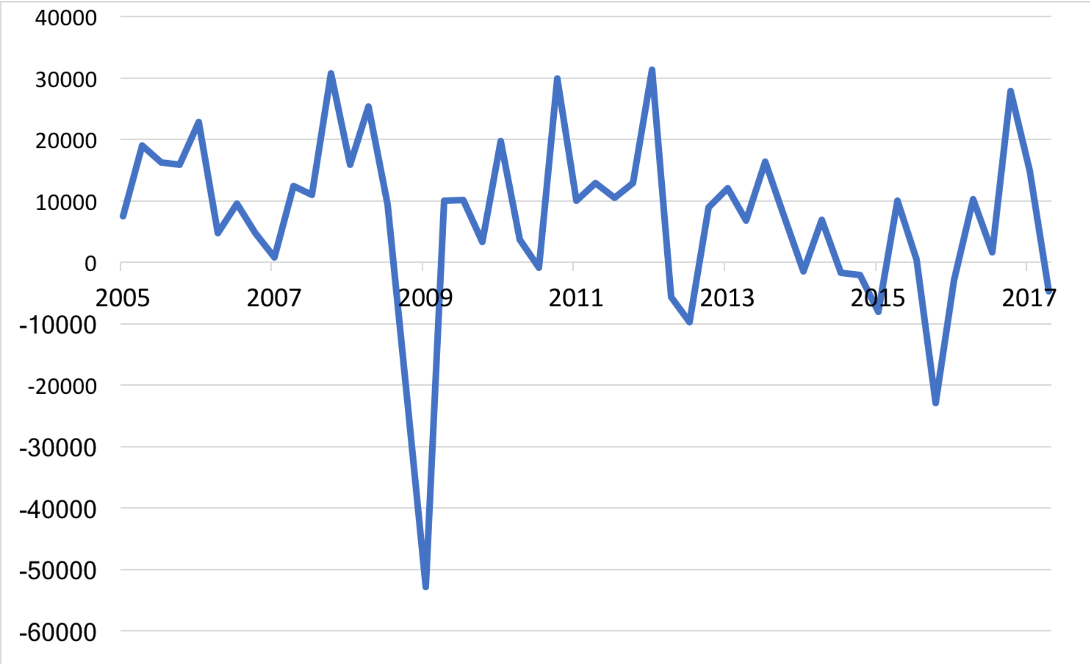


Figure 12: Annual gross domestic product changes. Millions NOK. Quarterly and seasonally adjusted data. Data source: Federal Reserve Bank of St. Louise

5. Short Empirical Review

5.1 Monetary Policy and Interest Rates

Cook and Hahn (1988) was the first to investigate the monetary pass-through effect to different interest rates. Their data consists of 75 changes in the Federal rate from September 1975 to September 1979. They implement their investigation by measuring one-day reactions in various American interest rates before and after a Federal target rate[16] change with the ordinary least squares method.

Cook and Hahn find evidence of a positive and significant correlation between changes in the Fed's target rate and short-term interest rates. As the maturity of the rates increases, the

[16] The American policy interest rate

correlation decreases. One percentage point increase in the Feds' fund rate is followed by an increase in 3-month Treasuries by 55-basis points[17]. The reaction in the 10-year Bond is inferior, with only 13 basis points. There is, however, positive and significant movements in the beginning of the yield curve. Accordingly, Cook and Hahn offer their support to the expectation hypothesis, as an alteration in the short-term interest rate creates fluctuations in the longer yield curves (Cook and Hahn, 1988).

Roley and Sellon (1995) documents strong effect between the Feds' fund rate and short-term interest rates. However, they conclude that the relation between the Feds' fund rate and long-term rates is weaker and variable.

Notwithstanding, Cook, Hahn, Roley and Sellon do not distinguish between expected and unexpected adjustments of monetary policy. According to the efficient market hypothesis (EMH) securities should always contain all information available (Kuttner, 2001).

For example, Goldberg and Deborah (2003) find reactions in 2- and 10-year German and American Bonds after publication of American economic news. Information regarding the production level, inflation and unemployment were all components which crated fluctuations in the Bonds. Accordingly, economic announcements, that is assumed to affect the Federal Fund's rate decision, are significant for longer term rates. Simultaneously, the research also states that several economic announcements have no impact on longer term rates.

Eeg (2007) investigate how market interest rates expectations react to key announcements. Including publications as inflation reports, unemployment reports and growth of the public credit rate. He highlights that market expectations are not directly observable. However, Norges Bank estimate market rate expectations from 3-months to 7 years[18]. As Goldberg and Deborah, Eeg finds a significant relationship between market rate expectations and the above-mentioned variables. Especially, news regarding the inflation level turns out to be significant for market rate expectations from 3 months to 7 years.

[17] 1 basis point is 1/100 percentage points.

[18] How Norges Bank estimates market interest rates expectations: «Documentation of the method used by Norges Bank for estimating implied forward interest rates»

The findings of Goldberg, Deborah and Eeg indicate that the market can be efficient and forward-looking. Their results suggest that securities are continually responding in conjunction with information related to the expected policy rate.

Accordingly, constant fluctuations in interest rates introduce complications to measure the policy rate pass-through effect to other interest rates. Therefore, Fransson and Tysklind (2016) argue that market rates, which have incorporated policy rate expectations, rarely display one-day reactions if these expectations are fulfilled by the central bank during a policy rate announcement.

However, by separating the expected policy change from the unexpected policy change, the pass-through effect is easier to grasp. Imagine a central bank which completely surprises the market with their policy rate decision. Observed one-day reactions in interest rates would therefore indicate how large impact the policy rate have on other interest rates (Kuttner, 2001). However, measuring monetary expectations can be a complex process.

5.2 Measure Monetary Expectations

In the literature, there are mainly two different approaches to measure monetary expectations. The first approach is to use the term structure of a financial instrument, such as a swap contract or a reference rate. The second approach is to use expectation surveys, which are issued by a central bank (Fransson and Tysklind, 2016).

With regard to the first approach, the swap contract directly reflects expectations regarding its underlying instrument. The swap contract normally reflects the average between the current level of the interest rate and the expected development, given the maturity. Accordingly, if the policy rate is the underlying interest rates in the contract, the swap rate can indicate market expectations concerning the development in the policy rate. E.g., if the swap contract exhibits a greater interest rate compared to the current policy rate, the swap rate implies a financial market which believe that the policy rate will increase, within the maturity of the swap contract (Fransson and Tysklind, 2016).

However, swap contract with policy rates as the underlying instrument in the contract, does not exist in many economies. Correspondingly, if a swap contract is applied as a proxy for policy rate expectations, the underlying asset must demonstrate high correlation with the desired policy rate (Fransson and Tysklind, 2016).

The second approach is questionnaire surveys. Several economies are issuing such surveys before every monetary meeting. These surveys often involve questions related to the expected policy rate. The largest advantage in favour to questionnaires is that they get an exact and directly measure of such expectations.

However, since these surveys are answered some time before an eventual rate adjustment, earlier stated expectations can differ from expectations developed after answering the survey. Accordingly, earlier declared expectations can deviate from actually predictions when the monetary announcement is approaching.

Another disadvantage revolves the lack of probability connected to the submitted answers. A firm can be ambivalent whether a central bank will change the policy rate, or not. Therefore, the submitted answer does not capture the uncertainty, which was affiliated to the firm's submitted answer. Hence, a vague statement is weighted in the forecast equally as a statement from a firm which is more certain in its beliefs (Fransson and Tysklind, 2016).

5.3 The Expected and Unexpected Reaction

Kuttner (2001) uses 1-month the Fed funds futures prices to measure monetary expectations in the United States. These Fed funds futures contracts are based on the forthcoming effective[19] federal funds rate, and are traded daily in the market. The effective funds rate shares a close relationship with the target funds rate[20].

Kuttner (2001) argue that the 1-month futures price, on the day prior to the announcement, only contain expectations concerning the approaching target rate. Kuttner assume that the target rate remains constant within the maturity of the fed futures contract, after an eventual adjustment in the target fed rate. Hence, with the target rate acting as a constant, the futures contracts can reflect exact expectations of the approaching target rate, prior to the monetary announcement.

[19] The effective federal funds rate is equivalent to the Norwegian interest rates; Nowa.
[20] The policy rate in the U.S.

Accordingly, eventual reactions in the Fed futures contracts between the day prior to the announcement and the actual announcement day suggest that the market were caught by surprise by the Fed. Therefore, Kuttner manage to segregate between the expected and the unexpected change in the target funds rate.

Kuttner finds a strong and significant relationship between the unexpected changes in the funds rate and both short- and long-term rates. Expected changes are generally small and/or insignificant (Kuttner, 2001).

Fransson and Tysklind (2016) must find another approach, since the instrument equivalent to Kuttner's proxy do not exist in the Swedish economy. Instead, Fransson and Tysklind select a swap contract as quantification for monetary expectations. The Stibor[21] interest rate serves as the underlying asset in the swap contract. Fransson and Tysklind highlights that this offer complications, as the Stibor does not directly measure Repo[22] rate expectations. Notwithstanding, by demonstrating high correlation and covariance between the Stibor and the Repo rate, their choice of monetary expectation proxy is well justified. Fransson and Tysklind adopt Kuttner's approach and measure fluctuations in the Stina contract between the day prior to a monetary announcement and the actual announcement day.

Their findings are similar to Kuttner's results; unexpected adjustments the Swedish repo rate display high and significant coefficients when explaining the short-term interest rates. However, an expected adjustment in the Repo rate also have a small, but significant impact to both the 3-month Stibor rate and the 3-month Swedish treasury. Fransson and Tysklind believe illiquidity in the Stibor and Swedish Treasury market is the explanation for the significance in the expected share of the Repo rate.

5.4 The Pass-Through Effect During Financial Stress

The pass-through effect from the policy rate to other interest rates has also been investigated during the financial crisis. Bernhardsen (2012) assumes that the increased spread between different policy rates and their associated 3-month money market rate contained maturity and

[21] Equivalent to other –IBOR rates, such as Libor and Euribor
[22] The Swedish policy interest rate

credit premiums. In times of financial instability premiums tend to increase. These premiums can directly alter money market without adjustments in the monetary policy.

Bernhardsen collected daily data from Norway, Sweden, Canada, Australia, Great Britain and the Euro area between 2007 and 2012. Furthermore, the data is categorized into three different samples. Therefore, the effectiveness of monetary policy can be investigated before, during and after the financial crisis. Bernhardsen estimates the following regression:

$$i - r^e \ = a + \ \beta \, r^e + c \, X \quad \text{(Bernhardsen, 2012, Pp. 2),} \qquad (9)$$

Where i is the 3-month money market rate related to the expected policy rate, r^e for each country. The expected policy rate is measured with overnight index swap (OIS) contracts.[23] A OIS is a swap contract where the overnight money market rate is allocated as the underlying instrument in the contract. The overnight money market rate is assumed to have a close relation to the policy rate. OIS contract are therefore considered to exhibit policy rate expectations, given a maturity. c is the VIX-index, which is an index capturing the volatility in the financial market (Bernhardsen, 2012).

Bernhardsen acknowledge that market participants are forward-looking. Consequently, the 3-month money market rate contains expectations regarding the forthcoming policy rate. E.g. expectations of a lower policy rate force money market rates down, ceteris paribus. If the actual policy rate is replaced with the expected policy rate, the pass-through effect is not accurately justified. Such an approach would not emphasize the policy rate expectations, which is contained in the 3-month money market rate. Accordingly, with the use of the actual policy rate, only the spread between the policy rate and the 3-month rate is captured. Furthermore, the measurement of the spread would not have been corrected for policy rate expectations (Bernhardsen, 2012).

Bernhardsen argues that the closer the estimated β is to zero, the larger pass-through effect. By equalizing the β to zero, the point is better displayed:

[23] The OIS market does not exist in Norway, however, Norges Bank estimate an OIS rate daily. Accordingly, Bernhardsen applies this estimate for the expected policy rate in Norway (Bernhardsen, 2012).

$$(1)\ i = a + \ r^e + c\,X \quad \text{(Bernhardsen, 2012, Pp. 2).} \qquad (10)$$

Bernhardsen's results suggest that monetary policy has a large pass-through effect on the 3-month money market rate. All estimated beta's (β) are close to zero before, during and after the financial crisis. However, the spread between the anticipated policy rate and money market rate is larger during the crisis for all countries. The author assumes that different premiums are the origin for a greater spread, as the VIX-index is positive and significant (Bernhardsen, 2012).

6. Econometric Specification and Definition of Variables

So far, I have demonstrated how Norges Bank guides the economy with their Folio interest rate, accompanied with appropriate liquidity management. I have also provided a brief description of varies interest rates, and their markets.

Further, research have suggested that the market can be efficient. Accordingly, interest rates tend to fluctuate with information, which is assumed to affect future policy rate decisions. Expectations concerning the policy rate should therefore be separated with the unexpected portion of the policy rate change. In such case, the pass-through effect from the policy rate to other interest rates would be easier to capture.

A great part of my thesis concerns finding an appropriate instrument for measuring Norwegian monetary expectations. Further discussion discloses this matter.

6.1 Monetary expectations measurement criteria

Due to daily quoting of interest rates, it is possible to isolate effects of monetary policy to interest rates more carefully. Therefore, the usage of a financial instrument as a monetary expectation proxy is preferred.

However, finding a suited Norwegian proxy for monetary expectations was a harder task than initially thought. The Norwegian derivative market is more limited compared to other advanced economies. In order to work ideally as a proxy for Folio rate expectations, the potential financial instrument should fulfil three criteria;

First and foremost, the financial derivative should have a close relationship with the Folio interest rate. This is the most important criteria. The chosen proxy needs to covary and correlate closely with the Folio interest rate. As the correlation increases, the more suitable the instrument is for expected monetary actions due to the assumable high pass-through effect from Folio rate to the chosen financial instrument.

Secondly, Norges Bank normally executes monetary meetings every sixth week. Accordingly, the duration of a financial derivative's maturity should not exceed six weeks. A proxy with maturity exceeding six weeks can contain expectations regarding two monetary meetings. Consequently, the instrument reflects expectations which are undesirable.

Finally, the proxy should be unaffected by different premiums; a proxy which either contains negative or positive premiums would indicate wrong expectations. With a positive premium present, the financial instrument demonstrates a higher term-structure compared to true term-structure of the Folio rate. Accordingly, an existing and positive premium in the financial instrument indicates a higher expected Folio rate, compared to true Folio rate expectations.

6.2 Evaluating proxy alternatives

The repurchasing agreement (Repo) was the first proxy alternative evaluated. The repurchasing agreement share similarities to a swap agreement. However, in the Repo agreement actual financial securities are traded, in contrast to the swap agreement.[24] The Repo rate is determined by selling the Treasury Bill, with an agreement to repurchase the Treasury at a settled maturity. Simplified; a financial agent agrees to buy a Norwegian Treasury for NOK 100 with an agreement to sell it back one year later. After the ended maturity, the Treasury displays a NOK 101 market value. Hence, the annual repo yield return corresponds to 1 percent (Norges Bank, 2017).

The Norwegian Treasury is assumed to have a high covariation and correlation with the Folio rate.[25] Therefore, the yield curve of the Treasury Bill was considered as an accurate indicator for the forthcoming Folio rate. However, as mentioned in section 4.6, the market for Norwegians Treasuries is illiquid. The illiquidity in the Treasury market contributes to an

[24] See section: 4.2.
[25] See figure 7.

illiquid repo market. Therefore, the price of the repurchasing agreement is not suited to reflect expected Folio rates (Kloster, 2000).

Moreover, the 3-month Nibor swap contract was considered as a proxy. However, due to the maturity, this instrument violates an important assumption; the proxy ought to contain expectations of one, and only one, monetary meeting. Thus, the 3-month swap rate would fail to reflect desired expectations concerning the forthcoming Folio rate announcement. The idea of using the 3-month swap rate was therefore evaluated as unsuitable.

6.3 Instrument for Expected Monetary Actions

The OIS market is absent in the Norwegian economy. However, Norges Bank estimates a rate which they believe is equivalent to the OIS rate on a daily basis. The estimation is based on the Nibor rate, subtracted for the Nibor premium. According to the information received by email, the premium is estimated through commutation between Norges Bank and the market. Further information from the financial market is also considered by Norges Bank.

Myklebust (2001) have documented how Norges Bank estimates the existing premium in the money market. Referring to section 4.7, the credit premium is considered to be absent in the Government Treasury rate. Accordingly, measuring the average spread between the Nibor rate and the Treasury rate should reflect the average credit premium existing in the money market.[26] However, it is beyond my knowledge if this method still applies to the obtained OIS estimate.

An OIS rate reflects the average between the spot Nowa rate and the expected Nowa rate, conditional on the maturity. Due to Norges Bank's liquidity management, the Nowa rate tends to be only a few basis points away from the Folio rate. Accordingly, Norges Bank defines their estimation of the OIS rate equivalent to market expectations regarding the Folio rate, given the maturity. Their identification of the OIS rate is also stated in an e-mail I received from Norges Bank:

«The OIS rate is based on conversations with market participants and Norges Bank's

[26] For a thorough description, see: «Documentation of the method used by Norges Bank for estimating implied forward interest rates» (Myklebust, 2005)

evaluation of the information received from the market. We argue that our OIS estimate is close to market expectations, regarding the Folio rate. However, the OIS rate is not traded, which can create potential error.»

Hence, the OIS rate can be interpreted as market expectations of the average Folio rate, given the maturity of the OIS contract. Norges Bank defines the OIS as follows (without maturity subscript):

$$OIS = (i - RP), \qquad (11)$$

where i is the Nibor rate and RP is the risk premium. From section 4.5 we remember that the Nibor rate displays average Folio rate expectations with an additional premium. Hence, if this premium is removed we are left with the market expectations concerning the average Folio rate (OIS) over a maturity.

6.4 Evaluating the OIS Estimate

After contacting Norges Bank, I was offered their estimated 1-month OIS rate. The obtained data consisted of daily changes in the 1-month OIS rate between 08.01.07 – 13.03.17. A thorough evaluation process was conducted, before I considered the OIS rate as the most appropriate proxy for the expected Folio rate.

Firstly, the 1-month OIS rate is based on the 1-month Nibor rate, which contains average Folio rate expectations with an additional premium. However, Norges Bank quantifies the existing Nibor-premium through communication and information obtained from the market, as stated above. Thus, the 1-month Nibor rate, absent for the premium, should therefore reflect market expectations for the average 1-month Folio rate. In figure 10, I display graphically how accurately the lagged 1-month OIS rate predict the observed Folio rate.

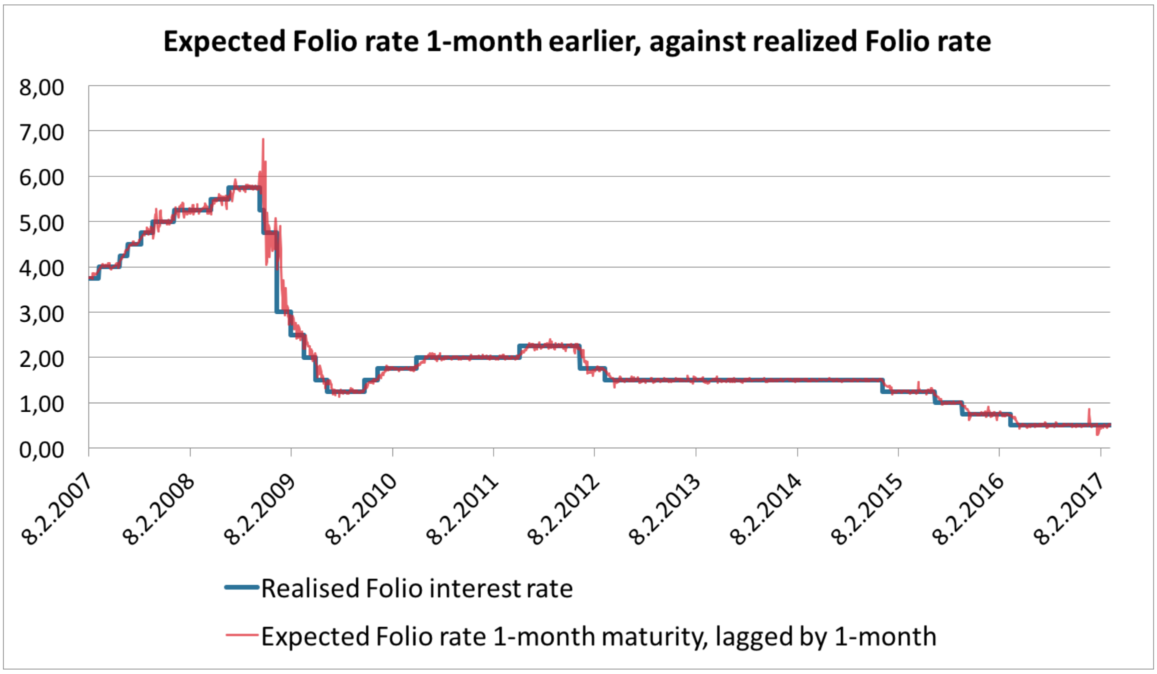


Figure 13: The 1-month OIS rate lagged by 1 month and the realized Folio rate. Daily observations. In percent. Data source: Norges Bank and Oslo stock exchange.

Secondly, the 1-month maturity is within a timeframe where the OIS rate reflects expectations concerning one, and only one, monetary meeting. Hence, the 1-month OIS rate reflects desirable expectations, which are necessary to its performance as a proxy.

Finally, the OIS rate is, by Norges Bank´s definition, absent for any premiums. However, since the OIS rate is an estimate of the expected Folio rate and not actual traded, estimation uncertainty errors are present. If the estimation error was a constant or deterministic process, these errors would be visible through time, since the estimated change would systematically be bias. In such case the estimation error could be adjusted. However, the errors are stochastic. The OIS rate can therefore be a bias instrument with regard to market expectations concerning the average 1-month Folio rate (Kuttner, 2001).

Further disadvantages of the OIS estimate are present. The 1-month OIS rate is, by definition (see equation 11), an endogenous independent variable when explaining the 1-month Nibor rate. The endogeneity problem is acknowledged as the simultaneity bias (Wooldridge, 2013, Pp:80-83). Whenever the 1-month Nibor rate changes, by construction, a portion of the 1-

month OIS estimate displays a symmetrically change. Accordingly, the 1-month OIS rate is determined jointly with the 1-month Nibor rate. Despite the subtracted premium, the OIS is still affected by the 1-month Nibor reactions.

However, since I have obtained the 1-month OIS rate, the simultaneity bias is only existent when the 1-month Nibor rate is regressed. Furthermore, the 3-month OIS rate have been implemented in explaining the 3-month Nibor rate before.[27] Nevertheless, due to potential endogeneity problems, I have chosen to remove both the 1-week and the 1-month Nibor rate, as dependent variables from this analysis.

Another endogeneity problem may be present if the estimated OIS rate where observed by the Nibor panel, prior to the listing of the Nibor rates. However, the daily estimates of the OIS rate are not shared with the public. I therefore exclude influence possibilities from the OIS rate to the Nibor rate. This means that Nibor rate is daily quoted, without any impact from the OIS rate.

Moreover, the OIS rate is calculated as a 5-day moving average, due to uncertainty in the estimation. There are both advantages and disadvantages with the moving average estimation. An obvious disadvantage is that an average measure of the OIS rate ensures to moderate daily fluctuations in the OIS estimate. Notwithstanding, the interval is short. The average quantification of the OIS should grasp daily and relevant fluctuations over the respective period of time.

However, it is expected that an average estimation of the OIS rate is likely to lighten potential noise in the data and mitigate the estimation error.

6.5 Defining the OIS Rate

Like Kuttner (2001), I have found it expedient to define the OIS rate, in order to display how expectations for the forthcoming Folio rate are obtained.

[27] See section: 5.4

The OIS rate can be interpreted as the conditional expectation of the average Folio rate, r_t^f, conditional of one monetary meeting occurring within the maturity m at date τ, hence:

$$OIS_{\ m,t} \ = E_{\tau}\frac{1}{d_m}\sum_{t\in m} r_{\tau}^f + \mu_t \tag{12}$$

Where the x represent today, d_m is the quantity of days within the maturity. The τ represents the monetary announcement day. The error term μ_t represents the uncertainty in Norges Bank estimation process. Correspondingly, the $OIS_{\ m,t}$ can be interpreted as market expectations for the average Folio rate over the next month (Kuttner, 2001).

Comparable to Kuttner (2001), I envision that market participants establish a 1-month OIS contract on date x and expect a monetary announcement at date τ. Norges Bank announces the Folio rate every sixth week. Consequently, market participants do not assume further changes in the Folio rate, within the 1-month OIS contract.[28] Accordingly, 1-month OIS rate will embody a weighted average between the spot Folio rate and the expected Folio rate, which is to be announced at date τ. The weighted average depends on the number of days between the OIS contract establishment date (x), and the announcement date (τ). Correspondingly, a 1-month OIS contract established on some date x, is defined as:

$$OIS_{m,x} = \frac{\tau - x}{d_m}\left[r_x^f\right] + \frac{d_m - (\tau - x)}{d_m}\left[E_x(r_\tau^f)\right] + \mu_t \tag{13}$$

Where d_m are the number of days in one month (m). τ represents the Folio announcement day and x serves as the establishment day for the OIS contract. Therefore, the term $(\mathrm{\tau} - \mathrm{x})$ represents the number of days between the OIS establishment day and the announcement day. Accordingly, $(d_m - (\tau - x))$ indicates the number of days remaining of the OIS contract, where the new Folio rate (r_τ^f) is prevailing. The variable r_x^f is the observed spot Folio rate on date x. $E_x(r_\tau^f)$ are expectations made at date x, regarding the future Folio interest, which is to be announced at date τ. known

[28] Due to the maturity of the 1-month OIS contract, this is only true if; $(\tau - x) <$ 1-month. If the OIS contract is established on a date (x) where the announcement (τ) is more than 1 month away, the expectations of a Folio rate announcement are absented in the OIS contract. Accordingly, the OIS contract is only reflecting the average of a known Folio rate, with the assumption that Folio rate is announced once, every sixth week.

E.g. an agent signs a 1-month OIS contract at date 1.1 with a settlement 1 month later, at date 1.2. The Folio announcement is dated to be at the 16.1. Hence, the OIS contract is established 15 days before the known monetary announcement ($15 = \tau - x$). Accordingly, the 1-month OIS rate emphasizes equally the current spot Folio rate and the expected Folio rate. Given the 1-month maturity. Accordingly, a 1-month OIS rate 15 days prior to a monetary meeting, is weighted:

$$OIS_{m,x} = \frac{15}{30}\left[r_x^f\right] + \frac{15}{30}\left[E_x(r_\tau^f)\right] + \mu_t \tag{14}$$

The 1-month OIS rate 15 days prior to a Folio interest rate announcement illustrates how agents weight the current and the forthcoming Folio rate equally, as both interest rates will have equal impact over the 1-month maturity. Correspondingly, the OIS rate is determined equally by the spot Folio rate and the approaching expected Folio rate.

Hence, on the date prior to a Folio rate announcement ($\tau - x = 1$), the market expects the monetary authorities to change, or not change, the Folio rate on date τ. The market assumes no further changes in the Folio rate within the maturity of the 1-month OIS contract. Consequently, a $OIS_{m,x}$ rate at the date prior to an announcement is defined as:

$$OIS_{m,x} = \frac{1}{30}\left[r_x^f\right] + \frac{29}{30} + \left[E_x(r_\tau^f)\right] + \mu_t \tag{15}$$

Hence, the $OIS_{m,x}$ rate prior to the monetary announcement day, represents nearly pure market expectations in regard to the Folio rate announcement occurring the next day.

6.6 Quantifying a Market Surprise

We have now obtained a measurement for the expected forthcoming Folio rate. Therefore, an apparent approach in obtaining the unexpected share of the Folio rate decision, would have been (Kuttner, 2001):

$$\Delta r_t^U = r_t^{Folio} - OIS_{t-1}^{1\,Month}, \tag{16}$$

where subscript t denotes the monetary announcement day, Δr_t^U is the unanticipated portion of the Folio rate adjustment. However, the $OIS_{t-1}^{1\,Month}$ contains the unknown and stochastic estimation error, μ_t. This error is likely to disturb the measurement of the unexpected portion of the Folio rate change. Therefore, I quantify the unexpected portion of the Folio rate decision by using the OIS rate, which is established after an eventual Folio rate adjustment is observed (Kuttner, 2001). Hence;

$$\Delta r_t^U = OIS_t^{1\,Month} - OIS_{t-1}^{1\,Month} \tag{17}$$

$OIS_{t-1}^{1\,Month}$ are market expectations of the average Folio interest over the next month, before the Folio rate announcement. While $OIS_t^{1\,Month}$ is the market expected average Folio rate for 1-month maturity, after Norges Bank announcement. Due to the 1-month maturity of the OIS contract and the assumption that Norges Bank only adjust the Folio rate every six week, the $OIS_t^{1\,Month}$ should accurately display the Folio rate after the announcement. Since both $OIS_t^{1\,Month}$ and $OIS_{t-1}^{1\,Month}$ contain the estimation error μ_t the error is likely to disturb the unexpected portion of the Folio rate estimate, I therefore treat the μ_t as a constant (Kuttner, 2001).

Accordingly, if the market correctly anticipated the approaching Folio rate, fluctuations between the OIS rates would approximately be zero. Therefore, if the market perfectly anticipates Norges Bank's monetary actions, then:

$$OIS_t^{1\,Month} - OIS_{t-1}^{1\,Month} \approx 0 \tag{18}$$

Values different from zero suggests that the market were caught by surprise by Norges Bank's decision. Hence, $OIS_t^{1\,Month} \neq OIS_{t-1}^{1\,Month}$ indicate that $OIS_t^{1\,Month}$ has been corrected, due to a Folio rate change. Correspondingly, a small Δr_t^U reflect a market which accomplished to anticipate the monetary actions made by Norges Bank.

At ended announcement day, the change/none-change in the Folio rate is observed. With the assumption[29] that no additional monetary Folio rate adjustments were to occur within the 1-month maturity, we can define the expected Folio rate (Δr_t^E) as:

[29] This assumption is violated once After the "Lehman Brothers" bankruptcy, Norges Bank press released news regarding an extraordinary monetary meeting, occurring the 15th October 2008.

$$\Delta r_t^E = \Delta r_t^{Folio} - \Delta r_t^U \tag{19}$$

6.7 Market Surprises

Figure (10) displays the expected and unexpected portion of Norges Bank's Folio rate decision. The grey bars denote the expected segment, while the orange bars indicate the share of which the market was surprised by Norges bank. The blue bars spot the actual Folio rate change.

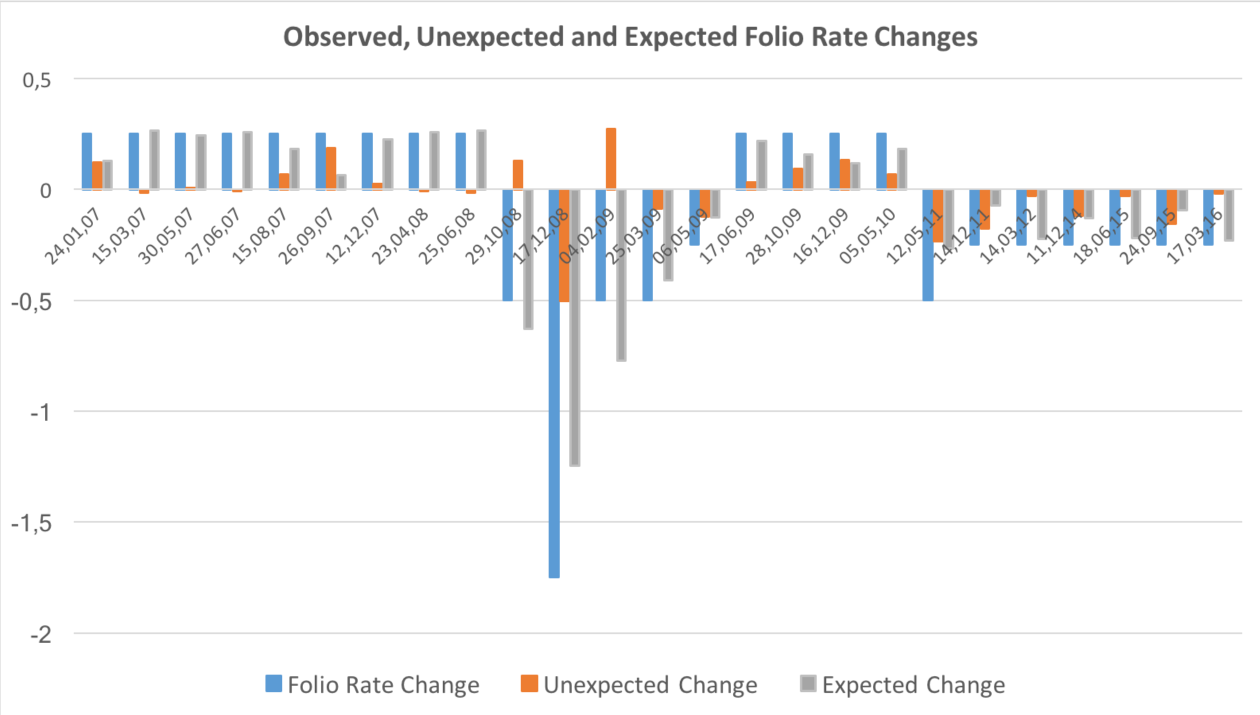


Figure 14; Observed and the unexpected and expected components in the Folio interest rate changes between 2007 and 2017.[30]

Until mid 2007 much of the Folio rate decisions were correctly anticipated by the market. This is evident, as the grey bars tend to be approximately at the same level as the blue bar. The largest exception during 2007, occurred on the 26th of September. Norges Bank elevated the Folio rate by 25 basis points. Norges Bank emphasized the increasing inflation rate. However, the interbank had experienced stress, affecting the money market rates to increase.

[30] Only actual Folio rate changes are included in the diagram. Data source: Norges Bank and Oslo stock exchange.

Therefore, the market anticipated that Norges bank would emphasize the financial instability and keep the Folio rate at the same level (Andersen and Lydersen, 2007).

We can observe a more uncertain market, simultaneously as the financial crisis develop. Obviously, the market understood that Norges Bank ought to decrease the Folio rate as a countercyclical measure to encounter the financial crisis. However, the magnitude of the Folio rate cuts seemed to be misunderstood by the market. During the financial crisis, market expectations have either been too small or too large, compared to Norges Bank actions.

Moreover, Norges Bank has managed to surprise the market in more recent time. At the 14th of December 2011, the majority of financial market assumed a cut in the Folio rate by approximately -25[31] basis points. However, Norges Bank surprised the market by cutting the Folio rate with -50 basis points. The market-surprise was eligible. This is best described with Norges Bank's former vice president[32] statement to the Norwegian newspaper E24, after their announcement (Brander, 2011);

"We considered to cut the Folio interest rate by 0,25 percent now, then reduce the rate with the equivalent amount in March. However, we wanted to be precautionary and cut the Folio rate by 0,5 percent now" (Brander, 2011, «*Kutter renten til 1,75 prosent*», Pp 1)

The same newspaper states that market participants were surprised by the magnitude of Norges Bank monetary decision. The newspaper refers to a Bloomberg survey, which was issued prior to the announcement the 14th of December 2011. 12 out of the 17 asked Norwegian economists stated that they anticipated a cut in the Folio rat by 25 basis points. The remaining 5 anticipated an unchanged Folio rate (Brander, 2011).

It appears that the market weighted the vice president's words heavily, as they anticipated no further Folio cuts the following meeting. However, 14th of March 2012, Norges Bank decided to decrease the Folio rate by an additional 25 basis points. The financial newspaper "Hegnar" described the Folio rate cut as an "Interest rate shock". According to a survey issued by

[31] The precise value of the expected Folio rate cut was -0,2652 percentage points decrease, considering my estimation (see appendix E, Table 101). The interpretation of the estimated value is that a small part of the market correctly anticipated the-0,50 percent Folio rate cut.

[32] Norges Bank former vice president; Jan F. Qvigstad (Brander, 2011)

Reuters, 11 out of 13 macroeconomic analysts expected Norges Bank to keep the Folio rate constant (Parr, 2012).

6.8 The European Government Bond

The uncovered interest parity hypothesis states that the differences in interest rate levels between countries must be equalized by the exchange rate. Otherwise, there exist arbitrage possibilities. Therefore, in an efficient market, where the uncovered interest parity hypothesis holds, the following relationship applies (Steigum, 2006, Pp 350-353):

$$i^N = i^{EURO} + E(\frac{EURO}{NOK}) \tag{20}$$

Where i^N is Norwegian interest rates, i^{EURO} is European interest rates (in EURO), while $(\frac{EURO}{NOK})$ is the expected exchange rate for EURO per NOK. Therefore, in an efficient market must supply and demand, combined with the exchange rate be in equilibrium (Steigum, Pp 350-353, 2006.)

Norway is small and widely open economy, with a floating exchange rate. Therefore, expansionary monetary policy is normally followed by a depreciating NOK (Steigum, 2006). This means that parity tend to hold. Accordingly, higher European interest cause a depreciation of the NOK.

A depreciating NOK affects the Norwegian economy mainly in two measures; (1) Ceteris Paribus, prices of foreign commodities are relatively more expensive, which increase the imported inflation in Norway. (2) Exporting Norwegian businesses, which directly compete with other foreign competitors, are relative less expensive with a depreciating NOK. More activity in the export industry in Norway further affects the unemployment rate and the wage formation (Norges Bank, 2004)

Assuming an efficient market, higher interest rates comparative to Norwegian interest rates create expectations of higher Norwegian inflation in the future. Expectations of higher inflation equalize expectations of a higher Folio rate in the future.

Steigum (2006) highlights the importance of exchange rate fluctuations in conjunction with interest rates for the small and open Norwegian economy. He states that interest parity normally holds. Hence a cut in the Folio rate is generally tracked by a depreciating NOK. Steigum further displays how the exchange rate affect the Norwegian economy:

$$\pi^{CPI} = (1 - v)\pi^{D} + v(\pi^{EURO} + E\left(\frac{EURO}{NOK}\right)) \text{ (Steigum, 2006, Pp 441)} \qquad (21)$$

Where π^{CPI} is the consumer price inflation in Norway, π^{D} is domestic inflation in Norway, π^{EURO} is the inflation in the Euro area. v is the weight of the impact of imported inflation in Norway. The estimated impact of imported inflation was estimated to be 0.3 in 2006.

Correspondingly, I have chosen to include the 5- and 10-year European Government Bond (EGB). The incentive for including the European Government Bonds is to grasp the link between Norwegian yields and European yields. It is expected that higher European interest rates create inflation expectations in Norway, which simultaneously trigger expectations of a higher interest rates in the future.

All Bonds are calculated as the daily change between the Folio rate announcement day and the day prior to the announcement. Daily data of the 5- and 10-year European Government Bond was acquired from the Swedish central bank, «Riksbanken».

Table 1: Descriptive statistics of all explanatory variables. All variables are estimated as the daily change between the Folio rate announcement day, and the day prior to the announcement. In percent.

Variable	**Quantity**	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
ΔUnexpected change	72	-0,001	0,003	0,104	-0,505	0,271
ΔExpected change	72	-0,037	-0,004	0,232	-1,245	0,266
Δ5-year EGB	72	-0.007	-0.001	0.067	-0.225	0.156
Δ10-year EGB	72	-0.005	0.001	0.059	-0.184	0.144

6.9 Analysis of the Dependent Variables

I have selected 9 Norwegian interest rates relevant to analyse the pass-through effect from the expected and unexpected Folio rate. All interest rates are already presented in section 4.5, 4.6 and 4.7.

Daily data was collected within the time frame; 08.01-2007 to 13.03-2017. All data was obtained from Norges Bank and the Oslo stock exchange. Interest rate maturities between 3 months and 10 years are included.

Each observation, regardless the maturity of the interest rate, is matched with the explanatory variables. Hence, the change is defined as the difference between the monetary announcement day and the day prior to the monetary announcement:

$$\Delta i_t^k = i_t^k - i_{t-1}^k \,, \tag{22}$$

where $k =$ 3-month, 6-month, …, 10-years, which indicate every interest rate maturity. t represents the monetary announcement day. Therefore, $t - 1$ is the day prior to the announcement. Within a timeframe of approximately 10 years, 72 monetary meetings were conducted by Norges bank.

The 3- and 6-month Nibor rate represent the interest rates with the shortest maturity. Observations from 08.01-2007 to 06.12-2013 was obtained from Norges Bank. The remaining observations were collected from the Oslo Stock exchange.

Table 2: Descriptive statistics for one-day change in the Nibor rates between the day prior to the announcement and the actual announcement day. In percent.

Variable	Quantity	Mean	Median	Standard Deviation	Minimum	Maximum
ΔNibor, 3-Month	72	-0,0004	0,010	0,122	-0,600	0,360
ΔNibor, 6-Month	72	-0,001	0,010	0,115	-0,480	0,400

Norwegian Treasuries are represented by the 3-, 6-, and 12-month maturity. All observations of the Treasury Bill rate are available at Norges Bank websites.

Table 3: Descriptive statistics for one-day change in the Treasury Bill rates between the day prior to the announcement and the actual announcement day. In percent.

Variable	Quantity	Mean	Median	Standard Deviation	Minimum	Maximum
ΔT-bill, 3-Month	70	0,009	0,003	0,009	-0,365	0,248
ΔT-bill, 6-Month	70	-0,018	-0,004	0,123	-0,740	0,196
ΔT-bill, 12-Month	70	-0,021	-0,001	0,133	-0,765	0,277

The long-term is represented by Government Bonds with maturities of 5- and 10-years. maturities. As the treasury, all data of Bonds are available at Norges Bank sites.

Table 4: Descriptive statistics for one-day change in Government Bond rates between the day prior to the announcement and the actual announcement day. In percent.

Variable	Quantity	Mean	Median	Standard Deviation	Minimum	Maximum
ΔBond, 5-Year	72	-0,010	0,000	0,065	-0,250	0,150
ΔBond, 10-Year	72	-0,006	0,003	0,061	-0,246	0,118

7. Econometric Specification

There have been mainly two different econometric approaches that have dominated the literature regarding the quantification of the impact from monetary policy to asset prices and interest rates. Either with vector auto regression (VAR) models, or with high-frequency asset prices data in conjunction with monetary shocks (Fawley and Neely, 2014).

VARs have the advantage to isolate aggregate monetary policy effects on different conventional macro variables, such as employment, inflation and production, often with a low frequency, such as monthly or quarterly data. However, to isolate the monetary impact on interest rates and asset prices with low-frequency data, is challenging. The greatest problem regarding such VAR analysis is the assumption to identify necessary causality. It is problematic to isolate the effects of monetary policy on economic variables. The causality issue was highlighted by Cristiano (1996), who questioned whether the effect on the economy arose by the endogenous monetary policy, or was triggered by an exogenous monetary shock. In this case, general monthly or quarterly VAR models have difficulties to localize causality (Fawley and Neely, 2014).

Therefore, a standard VAR model might fail to capture indirect causality occurring at a high frequency. Since financial participants are forward-looking, interest rates change due to expectations created by information. Accordingly, crucial information, which potentially can affect future monetary policy can therefore have an impact to the economy prior to the actual monetary announcement. This reaction is likely to be found in interest rates and asset prices (Fawley and Neely, 2014). Thus, the issue is highly applicable in regard to my topic.

Nonetheless, with high-frequency data, causality identification is easier. Other factors influencing pricing of interest rates are therefore narrower (Fawley and Neely, 2014).

I have chosen to use the multiple linear regressions model (MLRM) with the ordinary least square (OLS) method. The chosen quantitative approach is similarly to Kuttner (2001), Bernhardsen (2012) and Fransson and Tysklind (2016). Daily data have allowed me to investigate the relationship between the Folio rate and other rates over a short time interval.

7.1 The Ordinary Least Square Method - Hypothesis and Specification Tests Undertaken

I have used the statistical software; Eviews, in order to conduct multiple linear regressions with the ordinary least square (Hereafter «OLS») method. The OLS method require several assumptions to be fulfilled to explain a time series process. The first 5 assumptions are known as the classical Gauss-Markov assumptions:

(1) Linear in parameters
(2) No perfect collinearity
(3) Zero conditional mean
(4) Homoscedasticity
(5) No serial correlation/autocorrelation
(6) Normality

If assumptions from 1 to 3 are fulfilled we acknowledge that the OLS estimator produce unbiased coefficients. However, if all the above-stated assumptions are fulfilled, we say that our OLS estimator is BLUE (Best Linear Unbiased Estimator). With BLUE characteristics, the OLS produce estimators with the lowest variance among all estimators which are unbiased (Wooldridge, 2013, Pp:337-361, 110-113).

7.2 Linear Parameter

This assumption concerning Linear parameters states that the time series process we are modelling is linear in its estimated parameters/coefficients. The explanatory variables can be none-linear, like squared variables, in order to grasp the time process more accurately. However, estimated explanatory coefficients, together with the error term, assume a linear relationship with the explained variable (Wooldridge, Pp:337-343, 2013).

7.3 No Perfect Collinearity

Explanatory variables can be correlated. However, variables should not exhibit perfect correlation with each other. In the presence of a perfect collinearity problem, one solution is to drop one of the variables, which are perfectly correlated with the other variable (Wooldridge, Pp:80-82, 2013).

In order in to detect potential collinearity problems between my independent variables a correlation matrix was computed. The matrix suggests that none of the explanatory variables are highly correlated (Appendix B, Table 30). Moreover, for every model was the variance inflation factors (VIF) estimated. Values lower than 10 indicates no trances of high collinearity between the explanatory variables. All estimated VIF's suggest that none of the regressed models suffer from high collinearity complications[33] (Wooldridge, 2013, Pp: 94).

7.4 Zero Conditional Mean

The expected value of the error ($E(\mathrm{u_t})$), for each time period (t), given the independent variables, for all time periods, must be zero. Mathematically;

$$\mathrm{E}\langle \mathrm{u_t} | x_{1,t}, x_{2,t} \dots, x_{n,t} \rangle = 0 \qquad (23)$$

[33] Appendix C, Table: 34, 39, 44, 49, 54, 59, 64, 69, 74, 79, 84, 89, 94 and 99.

Where $u_t: t = 1, 2, \ldots, n$ represent the error term for each period of time (t) and $x_j: j = 1, 2, \ldots, k$ indicate every explanatory/independent variable for each time period (Wooldridge, 2013, Pp:338-340)

If this assumption is not upheld, the OLS estimator is biased. Hence, estimated coefficients do not represent the true time series process. The omitted variable bias or endogenous variables problem can be contributors for violation of the zero-conditional mean assumption. E.g. if an assumed important explanatory variable is omitted, it is expected that the impact of the omitted variable is contained in the error term. In this case, the expected error, given another explanatory variable, is not zero. We rather assume $Cov(u_i, x_i) \neq 0$ (Wooldridge, 2013, Pp:337-361). The discussion revolving endogenous variables were conducted in section 6.4.

7.5 Homoscedasticity

When we perform a linear regression, the variance in the errors, given the independent variables, must be constant. This means that our errors are homoscedastic:

$$\mathrm{Var}\langle \mathrm{u_t} | x_{1,t}, x_{2,t} \ldots, x_{k,t} \rangle = \sigma^2 \qquad (24)$$

Hence, that the variance in the errors, given the independent variables, remain constant over time (Wooldridge, Pp:340-344, 2013).

However, if the variance in errors are non-constant the assumption of homoscedasticity errors is violated. Non-constant variance in errors are known to be heteroscedastic. Correspondingly, the variance in the errors seem to depend on the independent variables through time. The OLS standard errors are not valid in the presence of heteroscedastic errors. Accordingly, the t-statistics, the confidence intervals, as well as the F-statistics in the OLS statistics are no longer valid. However, heteroscedastic errors are not producing a biased OLS estimator, but the OLS method is no longer the best approach (Wooldridge, Pp: 259, 2013).

The White test can be applied to check whether the independent variables are correlated with the errors. The white test squares the errors. The correlation between the squared errors and all independent variables, the squared of all the independent variables and finally the cross products of the independent variables is estimated. The non-statistical significance relationship between these terms indicates that the variance in the errors is constant (Wooldridge, Pp: 259, 2013).

However, in the presence of heteroscedastic errors, estimated heteroscedasticity-robust standard errors can be applied. The Newey-White method obtains robust standard errors and therefore allows heteroscedastic errors. Accordingly, the t-statistics and confidence interval is appropriate (Wooldridge, Pp: 261, 2013).

7.6 Serial correlation/autocorrelation

For the OLS method to be characterized as BLUE, the errors cannot be correlated through time:

$$Corr(u_t, \mathrm{u_s}) = 0, \forall\, t \neq s \tag{25}$$

This means that our errors in time t needs to be uncorrelated with the errors from time s. If the non-serial correlation assumption is violated, the errors display a relationship across time. The errors are namely autocorrelated or serial correlated. Autocorrelation can occur if the model is misspecified. Therefore, if we omitted an important and persistent variable, the persistency is likely to be captured in both error terms u_t, as well as the error term $\mathrm{u_s}$.

Trying to estimate a linear relationship, which is a non-linear process, is another example of model misspecification, and accordingly, be the reason for serial correlated errors (Wooldridge, 2013, Pp: 84-88).

The Breusch-Godfrey test detects serial correlation. Simplified; the Breusch-Godfrey test regressed OLS residuals obtained from an original model, with its lagged values. Under the null hypothesis are obtained coefficients not significantly different from zero. Hence, lagged residuals are not correlated with the OLS residuals (Wooldridge, 2013, Pp: 408).

In the presence of correlated errors can inclusion of other independent variables be a solution. Another approach is to estimate robust standard errors. Mentioned in 7.5, Newey-White robust standard errors allow heteroscedastic errors.

Time series regression need additional conditions, besides the classical Gauss-Markov assumptions, in order to produce BLUE results.

7.7 Stationarity

Stationarity is an important assumption in order to obtain consistent results with time series regressions. A stationary process describes a relationship between variables where the probability distributions are stable over time. Thus, whether the sample is from time t or $t + h$, should not affect the relationship between the variables. Correspondingly, the correlation is independent of time. To test whether a process is stationary or not, can be hard. However, it can be sufficient that the process is weakly stationary. A weakly stationary process or a covariance stationarity process needs three conditions to be fulfilled (Wooldridge, Pp: 368-372, 2013):

(1) The expectation of x_t needs to be constant, and the constant must be time-independent:

$$E[x_t] = \mu \tag{26}$$

(2) The variance of x_t needs to be constant, and again not dependent on time:

$$Var[x_t] = \sigma^2 \tag{27}$$

(3) The covariance of x_t and x_{t+h} is a function of h, and not a function of time (t):

$$Cov[x_t, x_{t+h}] = f(h) \neq g(t) \tag{28}$$

If these criteria do are violated, we have a nonstationary process.

A nonstationary process describes a relationship which varies through time. In such a case, linear regressions can produce spurious results. Hence, finding correlation between variables, which is non-existing (Wooldridge, 2013, Pp: 370, 618 and 854).

As already mentioned, my data sample contains daily changes. Therefore, my observations are by construction, similar to a stationary process, meaning that all of my defined variables are first differences processes:

$$\Delta i_{i,t} = i_{i,t} - i_{i,t-1} \, , \wedge \, i = 1, 2, 3, \dots, n. \tag{29}$$

Where i labels one of the n explanatory variables, while t indicates the time period.

Such series are acknowledged as a difference-stationary process and are often stationary (Wooldridge, Pp 383-385, 2013). I therefore believe that my data is stationary.

However, to reassure that my data are stationary, I have conducted the Augmented Dicky-Fuller (ADF) test, which can discover whether my data have a unit root, or not. The ADF test consider the hypothesis of nonstationary data (unit root present) under the null (Wooldridge, Pp 614-616, 2013). The null hypothesis was rejected for a 1 percent significance level for all variables, except the expected portion of the Folio rate, where was the null hypotesis was rejected for a 5 percent significant level[34]. I therefore conclude that my data are stationary processes.

7.8 Functional form

Functional misspecification can occur when the explanatory variables are not entirely capable of justifying the relationship with the explained variable. Referred to in section 7.6, functional misspecification can occur due to important omitted independent variables and therefore, endogenous independent variables. The Ramsey RESET test can detect whether models are well specified or misspecified. However, the RESET test lacks the ability to recognize the eventual cause of the misspecification (Wooldridge, Pp 296-302, 2013).

The Ramsey RESET states that the model is well specified under the null hypothesis. All RESET results for all models are found in the Appendix C. (Wooldridge, Pp 296-302, 2013).

7.9 Normality

Normality of the errors ensure that t-statistics and F-statistics have, respectively a t-distribution and a F- distribution. Therefore, confirmation of the normality assumption reassures that the obtained results regarding statistical significance of the independent variables individually (t-statistics) and jointly (F-statistics), are trustworthy (Wooldridge, 2013, Pp:343-345).

However, the central limit theorem states that the average of a random sample will approach a normal distribution with a zero mean as the sample size increase. Hence, with sufficient observations, non-normal residuals will not interfere with either the unbiasedness or the BLUE characteristics of the OLS method (Wooldridge, 2013, Pp 760-762).

[34] Appendix B, Table: 17-29.

Yet, how many observations which are included in "sufficient", are much debated in the literature. Warner (2008) consider 20 observations as a minimum, while Pett (1997) and Salkind (2004) recognize that many researchers suggest at least 30 observations (Corder and Foreman, 2009, p.2 footnote). Due to my sample size, potential findings of non-normal errors should not interfere with the BLUE features of the OLS.

Jarque-Bera normality tests were undertaken to identify the normality of the residuals for all models. The Jarque-Bera normality test define the null hypothesis as normality in residuals (El-Salam, 2013). The results are discussed in section 9 and are visible in the appendix C.

8. Estimating the Pass-Through Effect

8.1 The model

Inspired by Fransson and Tysklind (2016, Pp 49), I will quantify the Folio rate pass-through effect to other interest rates by estimating the following OLS regression:

$$\Delta R_t^i = \alpha + \beta_1^i \Delta r_t^E + \beta_2^i \Delta r_t^U + \beta_3^i \Delta r_t^{EGB} + \varepsilon_t^i \,, \qquad (30)$$

subscript t denotes the moment of a monetary announcement. ΔR_t^i is changes in different dependent interest rates. Δr_t^E is changes in anticipated monetary policy, Δr_t^U is changes in unanticipated monetary policy, while Δr_t^{EGB} is changes in the European Government yields.

The hypothesis is that the coefficient β_1^i is trifling for short-term interest rates as well as long-term interest rates. My hypothesis corresponds to the efficient market theory. Accordingly, expected adjustments in the Folio rate should already be incorporated in the interest rate.

In contrast, it is expected that β_2^i is strongly significant, since unexpected monetary actions should immediately trigger reactions in other interest rates. The magnitude of the pass-through effect is increasing as the coefficient is approaching 1. Hence, a $\beta_2^i = 1$ suggest a full pass-through effect from the unexpected portion of the Folio rate to other interest rates.

Since the Norwegian economy is dependent and affected by the global economic environment, it is expected that an increase in European Government yields amplifies Norwegian long-term interest rates. Therefore, β_3^i is expected to be positive. The 5- and 10-

year European Bond is coordinated with the maturity of the Norwegian Bonds. Hence, these explanatory variables are only included when the 5- and 10-year Norwegian yields are explained.

8.2 Timing of the Data

The Nibor rate is published every day at 12 pm, without further changes that day. Before 2013, Norges Bank announced their monetary decision at 14.00 pm. Therefore, before 2013 the Folio rate decision was unknown when the Nibor panel published the Nibor rate on date t. Thus, in order to find evidence of the pass-through effect, the Nibor panel most obviously have the possibility to react to Norges Bank decision. Hence, a potential new Folio rate needs to be observed. Accordingly, an eventual correction in the Nibor rate, due to a new Folio rate, is only observed at date $t + 1$. Therefore, observed adjustments in the Nibor rate is estimated between t to $t + 1$ from 2007 to 2012.

However, from 2013, Norges Bank began to announce the Folio rate decision at 10.00 pm. Accordingly, from 2013 the Nibor panel had the possibility to respond to an eventual new Folio rate at date t. Therefore, potential reactions in all Nibor rates are traced between $t - 1$ and t between 2013 and 2017.

As explained in section 6.5, the 1-month Nibor rate is related to the OIS rate structure. Therefore, the estimated adjustments in the OIS rate are equivalent to the estimated changes in the Nibor rate. Accordingly, from 2007 to 2012 the adjustments in the OIS rate are estimated from t to $t + 1$. From 2013 to 2017 the changes are observed between $t - 1$ and t.

Norwegian Treasury bills and Bonds are quoted at ended business day (16.20 pm) (Oslo Stock Exchange, 2017). Therefore, the Folio rate decision is observed at date t, before Norwegian Bonds and Treasuries are quoted in the market. Consequently, adjustments in the Treasuries and the Bonds are calculated as the difference between t and $t - 1$ throughout the sample.

8.3 Extraordinary Monetary Meeting

The 8^{th} of October 2008, a press release from Norges Bank declared news concerning an extraordinary monetary meeting. The extraordinary meeting was dated the 15^{th} of October.

The press release further stated that Norges Bank was to evaluate the Folio interest rate, due to growing instability in the financial market. It was also announced that the original scheduled monetary meeting, dated 29th of October, was still to be held. Therefore, within two weeks, Norges Bank held two monetary meetings.

As it transpires, from the 8th of October financial participants were aware of the occurrence of two monetary meetings scheduled within the two-week period. Thus, the OIS rates at the 14th of October (the day prior to the extraordinary meeting 15th of October) contained Folio rate expectations regarding two monetary meetings (the 15th and 29th of October), and not only one.

Because the OIS rate, at the 14th of October, contained expectations concerning two monetary meetings, the OIS rate was violating an important criterion; the designated proxy should only contain expectations for one, and only one, monetary meeting. Thus, the 14th of October OIS rate fails to reflect the expected Folio rate, which is to be announced the following day. Therefore, I have chosen to exclude observed fluctuations in the OIS rate between 14.10.2008 - 15.10.2008 from the sample.

9. Results

So far, I have illustrated how I obtained a measurement of the expected and unexpected quantity of a Folio rate decision. Since market participants are forward-looking, I argue that interest rates reflect all information available. Therefore, my hypothesis state that interest rates only react to news.

It is expected that the Folio rate has a close relationship between shorter maturities. Since the future Folio rate is assumed to dominate longer maturities, it is anticipated that the pass-through effect is minor for long-term interest rates.

Moreover, in order to analyse the Folio rate pass-through effect to other interest rates, I have tried to exclude the many components, which affects interest rates. This is implemented by measuring interest rate fluctuations within a short time interval, before and after a Folio rate decision.

Obtained results from the whole sample are presented first. Regressions conducted for the post-financial crisis sample follows.

Finally, all conducted test statistics are found in appendix C. Original outputs are located in Appendix D. The numeration of the models in the text are equivalent to the numeration in the appendix.

9.1 The Nibor Interest Rates

First of all, both Nibor rate models accept the null hypothesis in the Ramsey RESET test, suggesting that my models are well specified. According to the Breusch-Godfrey LM test, none of the residuals are correlated over time. I therefore exclude autocorrelation in both models.

However, the 3-month Nibor model rejects the null hypothesis in the White test. Therefore, the variance in the residuals seem to fluctuate with the independent variables. This is discussed further below. The Jarque-Bera test suggests that the residuals are not normally distributed. I still consider the OLS method with characteristics as unbiased and BLUE, referring to the discussion in section 7.9.[35]

---

[35] All test statistics for the 3-month model is found in Appendix C, table 31-35, while results are found in Appendix D figure 17.

Table 5: Regressions with 3- and 6-month Nibor rate as dependent variable. In percent. Robust standard errors are obtained with the Newey-West estimator in model 1. See "note" below table 5.

Independent variables	Nibor 3-Month (Model 1)	Nibor 6-Month (Model 2)
Intercept	0.001 (0.006)	-0.008 (0.006)
$\boldsymbol{Expected_t}$	0.030 (0.028)	0.187 (0.033)
$\boldsymbol{Unexpected_t}$	1.040*** (0.062)	0.935*** (0.073)
Observations	72	72
R^2	0.814	0.711
Adjusted R^2	0.808	0.703
(Wald) F-statistics	(175.496)	85.239
P > F (Wald Statistics)	(0.000)	0.000

Note: *, ** and *** represent coefficients, which are significantly different from zero. Respectively on a 0.1 (p<0.1), 0.05 (p<0.05) and 0,01 (p<0.01) percent level. In the 3-month Nibor model (1), robust standard errors are obtained with Newey-West estimator. The Newey-West estimator corrects for heteroscedasticity in the residuals. Wald F-statistics and Wald Prob > F are in brackets when applied.

Table 5 reveals two key findings. Firstly, the unexpected portion of the Folio rate is strongly significant, while the expected segment of the Folio rate change is small and insignificant. These findings confirm my hypothesis and suggest that market participants only react to the unpredicted share of the Folio rate.

Secondly, the Folio rate and the 3-month Nibor rate have a one-to-one relationship. It is expected that an unpredicted 100-basis point correction in the Folio interest rate increase the 3-month Nibor rate by 104 basis points. These results propose a complete Folio rate pass-through effect to the 3-month Nibor rate.

However, the 3-month Nibor rate model (1) rejects the null hypothesis in the White test (Appendix C, table 33). These results indicate that the residuals are heteroscedastic. Heteroscedastic residuals can arise when the residuals are increasing, or decreasing alongside the value of the independent variables (Wooldridge, 2013, Pp 258-263). Such behaviour can be explained by the events unfolding during the financial crisis.

In the beginning of the 2007, Norges Bank began to increase the Folio rate. The peak is observed in 25th of June 2008 with 5,75 percent. The financial crisis arose and Norges Bank cut the Folio rate repeatedly, with abnormal magnitude. Figure 12 also indicate that the market expectations concerning the magnitude of the Folio rate cuts increased. By September 2009, the Folio rate had reached a 1,25 percent level. From then on, the Folio rate has fluctuated within the 0.5 – 2.0 percent interval.[36]

Lund, Tafjord and Øwrejhnsen (2016) investigate the magnitude of the premium in the Nibor rate from 2008 to 2016. They conclude that the credit premium was large during the financial crisis. Their finding is supported by investigating reactions in the 3-month Nibor rate after a Folio rate decisions (Appendix E, figure 31). E.g. On the 29th October 2008 Norges Bank cut the Folio rate by 50 basis point. However, the reaction in the 3-month Nibor is measured to be a 36-basis basis point increase. On the 17th of December 2008, Norges Bank decreased the Folio rate by incredible 1.75 percentage points, while the 3-month Nibor rate only declined by 60 basis points.

As stated in section 4.5, the Nibor rate is defined as the expected Folio rate with an additional premium. Therefore, a greater premium should directly affect the Nibor rate. The reactions mentioned above, suggest that the premium in the 3-month Nibor rate was larger, compared to the Folio rate pass-through effect. Accordingly, large premiums in the Nibor rate can create sizeable residuals, since the premium directly can increase the spread between the Nibor rate and the Folio rate. Thus, the effeteness of monetary policy was weakened. Consequently, the unexpected and expected Folio rate decisions are assumed to affect the absolute change in Nibor rate less.

[36] See figure 1 in section 2.2.

Hence, the non-constant variance in the residuals is likely to be caused by the financial crisis, which is characterized with (1) large Folio rate cuts, (2) uncertainty in the market, and (3) large premiums in the Nibor rate. The residual plot in the 3-month Nibor model suggest a larger variance in the residuals in the beginning of the sample, compared to the end of the sample (Appendix E, figure 32). The same reasoning could also explain non-normality residuals.

However, the post-financial crisis period was dominated by a low Folio interest rate and more predictable monetary decisions[37]. Correspondingly, there are reasons to believe that heteroscedasticity and non-normality residuals are absent after the financial crisis. This is investigated later in the thesis.

Regarding the 6-month Nibor model, the reaction is inferior, compared to the reaction in the 3-month Nibor. However, if Norges Bank extends the Folio rate by 100 basis points unexpectedly, the 6-month Nibor rate is expected to increase with 93,5 basis points. In addition, the expected portion of the Folio rate is weak and not significant.

According to the coefficient of determination, the unexpected change in the Folio rate explains 80,8 percent of the variation in the 3-month Nibor rate, while the unexpected change justifies 71,1 percent of the variation in the 6-month Nibor rate.

Overall, the Folio rate pass-through effect to the Nibor rates appears to be large and robust.

9.2 Government Treasury Interest Rates

The results obtained from the original Treasury models fails to accept the null hypothesis in the Ramey RESET test. However, the graph of the residuals in the 3-month Treasury model suggests the cause of the misspecification.

[37] See figure 12 in section 6.7.

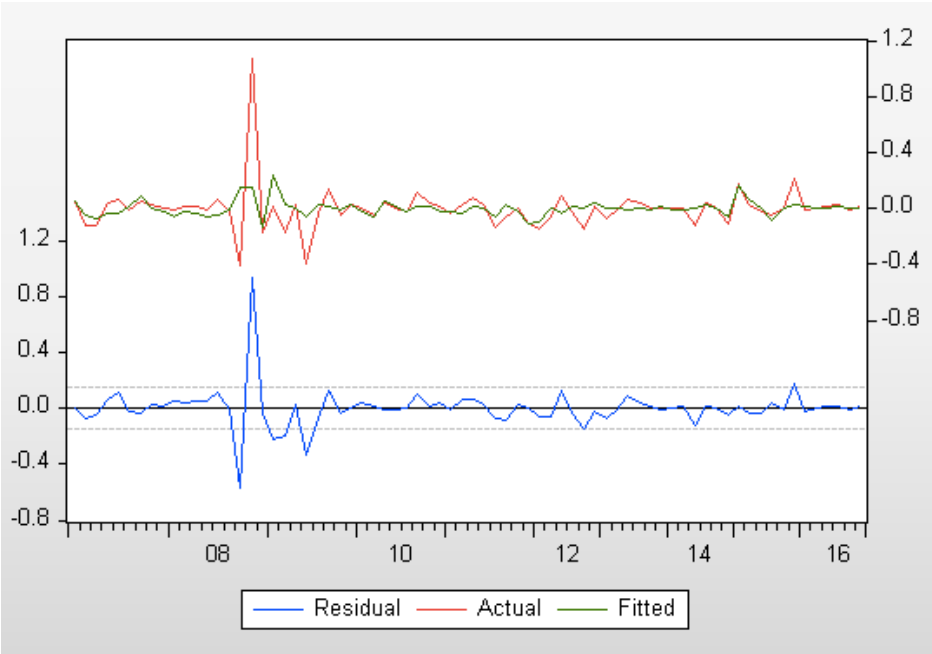


Figure 15: Graph of residuals in original 3-month Treasury model.

Two large outliers stand out. They refer to the monetary meetings occurring 24th of September 2008 and the following meeting, dated 29th of October 2008. Residuals are measured to -0,56 and 0,93 percent, respectively.

As stated in section 4.8, the credit premium was elevating in the Nibor rates after the Lehman Brothers announced their bankruptcy (15th of September 2008). Therefore, the Norwegian interbank market explored liquidity substitute possibilities. This resulted in an exploding demand for Government Treasuries. Consequently, the higher demand increased the Treasury price. This is apparent when analysing movements in the Folio rate and the 3-month T-bill rate after the monetary announcement 24th of September. While the Folio rate remained unchanged, the 3-month Treasury rate decreased by 41,36 basis points.

As referred to in section 4.8, Norges Bank establishment of the "swap agreement" (24th of October 2008) gave the Norwegian banks the opportunity to swap covered Bonds with newly issued Treasuries, which is evident in figure 14. Norges Bank and the Government have never conducted similar monetary policy before. The policy measure affected the Treasury market immediately. The effect is apparent when investigating the first monetary meeting (29th of October 2008), after the newly adopted and unconventional market operation measure; While

Norges Bank opposed the financial crisis by a 50-basis points cut in the Folio rate, the 3-month Treasury rate responded by increasing with 20 basis points.

In these two events, it is reasonable to believe that the Government Treasury price was highly affected by irregular supply and demand.

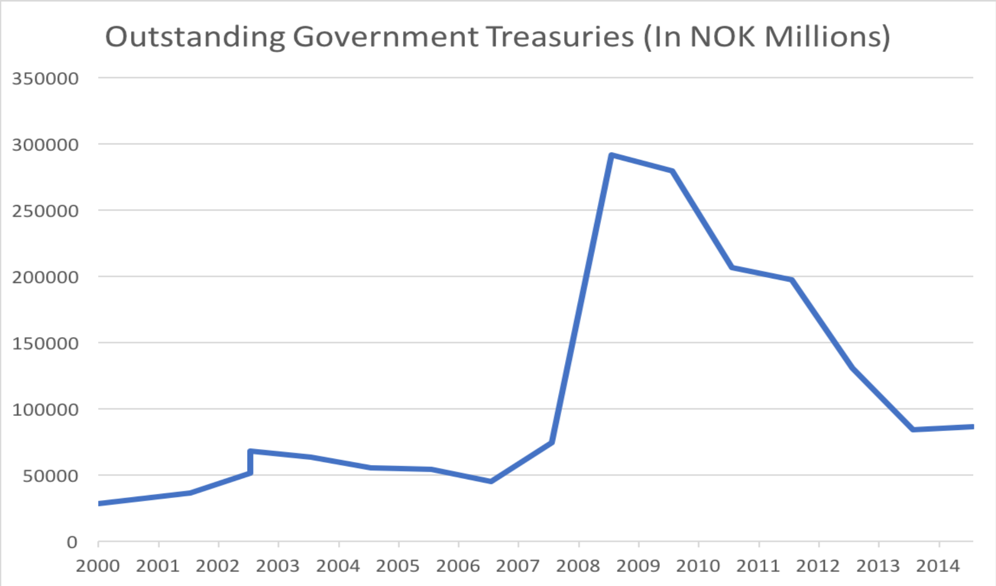


Figure 16: Outstanding Government Treasuries. In NOK millions. Annual data. Data source: Oslo stock exchange.

To resolve whether to retain or exclude outliers is a hard task and should be evaluated carefully (Wooldridge, 2013 Pp 316-321). However, I argue that the two observations represent Treasury rates, which are fundamentally different from rest of the sample. Due to immense financial stress and its role as the instrument in unconventional expansive market operations, the two observed Treasury reactions are likely to violate the average price formation of the Treasury. Accordingly, I believe that the average relationship between the Treasury and the Folio rate is captured more accurately by excluding the two observations. Therefore, I have decided to remove the above-mentioned observations from the sample.

When the two outliers are removed, all Treasury models accept the null hypothesis of the Ramsey RESET test. The null hypothesis in the Breusch-Godfrey LM test is accepted for all Treasury models, expected the 12-month maturity. This is discussed further below. We reject the alternative hypothesis in the White test for all Treasury models. These results indicate that the residuals are homoscedastic, which is preferred. All models reject the Jarque-Bera test indicating that the residuals are not normally distributed.[38]

Table 6: Regressions with 3-, 6- and 12-month Treasury Bill rates as dependent variables. In percent. Robust standard errors are obtained with the Newey-West estimator in model 5, see “note” below the table.

Independent variables	Treasury Bill 3-Month (Model 3)	Treasury Bill 6-Month (Model 4)	Treasury Bill 12-Month (Model 5)
$\boldsymbol{Intercept}$	-0.006 (0.010)	-0.002 (0.005)	-0.003 (0.005)
$\boldsymbol{Expected_t}$	0.024 (0.041)	0.076 (0.027)	0.125*** (0.029)
$\boldsymbol{Unexpected_t}$	0.455*** (0.092)	0,334*** (0.060)	0.423*** (0.070)
Observations	70	70	70
R^2	0.312	0.457	0.557
Adjusted R^2	0.291	0.441	0.544
(Wald) F-statistics	15.199	28.216	(100.231)
(Wald) P > F	0.000	0.000	(0.000)

Note: *, ** and *** represent coefficients, which are significantly different from zero. Respectively on a 0.1 (p<0.1), 0.05 (p<0.05) and 0,01 (p<0.01) percent level. In the 12-month Treasury model (5), robust standard errors are obtained with Newey-West estimators, which correct for autocorrelation in residuals. Wald F-statistics and Wald Prob > F are in brackets when applied.

First of all, coefficients representing the unexpected alteration in the Folio rate are significant for 1 percent significance level, for all the Treasury models. The largest reaction is found in the 3-month Treasury bill with 45,5 basis points, considering an unpredicted 100-basis point Folio rate change. Compared to the Nibor models, all significant coefficients for the Treasury models are smaller. The same applies for the coefficient for determination.

[38] All test statistics for the Treasury models are found in Appendix C, table; 41-55. Original outputs are visible in Appendix D, figure; 19-21.

Further, the expected share of the Folio rate adjustment is small and insignificant. The only exception is found in the 12-month Treasury model. If Norges Bank increase the Folio rate by 100 basis points, the estimated pass-through effect to the 12-month Treasury bill is 54,8 basis points, combining both the expected and unexpected components of the Folio rate change.

Moreover, the 12-month model fails to accept the null hypothesis in the Breusch-Godfrey LM test (Appendix C, table 57). Hence, residuals display correlation through time. Accordingly, robust standard errors are obtained with the Newey-West estimator, which allow serial correlation in the model.

The lack of turnovers in the Treasury market could be an explanation for both the autocorrelation problem and why the expected share of the Folio rate exhibits a significant impact in the 12-month model. Less turnovers can create friction in the market, which will possibly delay market response to the Folio rate (Fransson and Tysklind, 2016).

The same reasoning can explain why the unexpected share of the Folio rate has an inferior impact on the Treasury rates, compared to Nibor rates with corresponding maturity (Evjen, Grønvold, Gundersen, 2017).

However, unconventional market operations conducted in late 2008 and through October 2009 increased the supply of Government Treasuries. Accordingly, the extended supply of Treasuries, combined with the higher demand is likely to have increased the frequency of turnovers. Stronger reactions should therefore be visible in the period after October 2009. Reactions in Treasury rates after the financial crisis are investigated later in the dissertation.

9.3 Government Bond Interest Rates

As stated, I have chosen to include the European Government Bond (EGB) in the Norwegian Bond models. Referring to section 8.1, the maturity of the applied European Bond corresponds to the maturity of the Norwegian Bond.

Firstly, all long-term Bond models accept the null hypothesis in the RESET test. Models are therefore well specified. The null hypothesis is also accepted in the Breusch-Godfrey LM test, indicating no correlation between the residuals within the sample. However, the 10-year Bond model rejects the null hypothesis in the White test. Robust standard errors are therefore used to obtain valid t- and F-statistics. Moreover, the null hypothesis in the Jarque-Bera test suggests that the residuals are normally distributed.[39]

Table 7: Regressions with 5- and 10-year Norwegian Bond interest rates as dependent variable. In percent. Standard errors are measured with Newey-West estimator in the 10-year Bond model (model 7), see note under displayed output.

Independent variables	5-Year Bond (Model 6)	10-Year Bond (Model 7)
$\boldsymbol{Intercept}$	-0.005 (0.006)	-0.000 (0.004)
$\boldsymbol{Expected_t}$	0.053* (0.028)	0.044*** (0.016)
$\boldsymbol{Unexpected_t}$	0.188*** (0.062)	0.099** (0.048)
5-*year EGB*	0.412*** (0,096)	Not Included
10-*year EGB*	Not Included	0,696*** (0.078)
Observations	72	72
R^2	0.396	0,598
Adjusted R^2	0.369	0.581
(Wald) F-statistics	14.848	(59.418)
P>F (Wald)	0.000	(0.000)

Note: *, ** and *** represent coefficients, which are significantly different from zero. Respectively on a 0.1 (p<0.1), 0.05 (p<0.05) and 0,01 (p<0.01) percent level. In the 10-year Bond model (7), robust standard residuals are obtained with Newey-West estimators, which correct for heteroscedasticity residuals. Wald F-statistics and Wald Prob > F are in brackets when applied.

[39] All test statistics for the Bonds models are found in Appendix C, table; 56-65. Original outputs are visible in Appendix D, figure; 22 and 23.

Concerning the 5-year Bond, the unexpected Folio rate adjustment is highly significant, while the predicted Folio rate is significant for a 10 percent level. Therefore, the expected monetary decision is considered to not affect the 5-year Bond. However, if Norges Bank surprise the Bond market by a 100-basis point alteration in the Folio rate, the 5-year Bond is expected to increase by 18,8 basis points.

For the 10-year Government Bond, the unexpected portion of a monetary decision is less significant and the coefficient is smaller, compared to the 5-year security. Moreover, results suggest that the predicted Folio rate adjustment has a highly significant impact on the 10-year Bond. Even though the Bond market correctly anticipate a 100-basis point movement in the Folio rate, the Bond rate still increase by 4,4 basis points. By combining both the significant coefficients, the estimated pass-through effect from a 100-basis point Folio rate correction is 14,3 basis points.

Equivalent to the Norwegian Treasury market, the Bond market is characterized as illiquid (Evjen, Grønvold, Gundersen, 2017). Correspondingly, reactions caused by the Folio rate might work with a lag. This could be the explanation for the significant coefficient representing the expected portion of the Folio rate in the 10-year Bond model. Another explanation could be non-perfectly rational and/or fully informed financial market.

The Folio pass-through effect to long-term Bond rates is small. Nevertheless, Frawley and Neely (2014) have gathered studies, which investigate the pass-through effect in the U.S. Coefficients representing the unexpected portion of the monetary policy are estimated within a basis point interval of 18,2 to 48,1 for the 5-year American Bond. The interval is between 2,7 to 42,6 basis points for the same coefficient, when explaining the 10-year Bond (Fransson and Tysklind, 2016).

Fransson and Tysklind (2016) measure the pass-through effect in the Swedish economy, an economy which is more comparable to the Norwegian one. Only unexpected policy rate adjustments are significant, coefficients display a 32- and 20-basis point reaction for respectably the 5- and 10-year Swedish Bond. My findings are similar, but inferior, compared to the Swedish economy.

Since these financial instruments have extensive maturities, the pass-through effect is expected to be smaller, compared to instruments with shorter maturities. Expectations concerning future Folio rate decisions are assumed to be weighted more heavily. Obtained results are anticipated and in accordance with interest rate theory.

Finally, the results indicate that Norwegian long-term yields tend to follow foreign yields. The result is anticipated, as the development in a small and open Norwegian economy is affected and depends on the economic condition in Europe. My findings suggest that the relationship is stronger, as the maturity increase.

9.4 The Monetary Pass-Through Effect After the Financial Crisis

An effective monetary policy presupposes a strong relationship between the Folio rate and short money market rates, which furthermore ought to affect long-term rates. Therefore, I want to investigate whether the effectiveness of the Norwegian monetary policy was disturbed by the subprime financial crisis.

Due to limited observations, I have decided to differentiate between the whole sample period and the period after the financial crisis. Samples collected from the period before, during and after the financial crisis would have been more satisfying. However, significant and superior coefficients in the period after the financial crisis, compared to the whole sample size, indicate that the financial crisis had a negative influence on the Folio rate pass-through effect.

As mentioned in section 5.4, Bernhardsen define the end of the financial crisis as January 2009 for several countries, Norway included. However, Norges Bank decreased the Folio rate the four following monetary meetings after January 2009. The first positive Folio rate adjustment is observed 28th of October 2009. Furthermore, 19th of October 2009[40] the Government implemented the last unconventional measure in the money market. I therefore argue that October 2009 is a more appropriate time for defining the end of the financial crisis in Norway.

[40] See section: 5.5

Regressions presented in table 8, 9 and 10 are identically as previous ones, however the sample is now collected from 19th of October 2009 to 15th of December 2016.

9.5 The Nibor Rates - after the financial crisis

All test statistics for the Nibor models, post-financial crisis, are found in Appendix C, table; 66-73. Original outputs are visible in Appendix D, figure; 24 and 25.

Table 8; Regressions with 3- and 6-month Nibor rate as dependent variable.
Sample is collected between 19.10.2009 and 15.12.2016 (post financial crisis). In percent.

Independent variables	Nibor 3-Month (Model 8)	Nibor 6-Month (Model 9)
$Intercept$	-0.005 (0.004)	-0.007 (0.006)
$Expected_t$	-0.037 (0.048)	-0.046 (0.060)
$Unexpected_t$	0.915*** (0.064)	0.809*** (0.080)
Observations	48	48
R^2	0.820	0.696
Adjusted R^2	0.812	0.703
F-statistics	102.862	51.622
P > F	0.000	0.000

Note: *, ** and *** Note: *, ** and *** represent coefficients, which are significantly different from zero. Respectively on a 0.1 (p<0.1), 0.05 (p<0.05) and 0,01 (p<0.01) percent level. OLS standard errors are displayed in brackets.

Compared to the whole sample, the unexpected share of the Folio rate decision is still highly significant, while the expected share of Norges Bank decision is minor and insignificant after the subprime crisis.

Nevertheless, the coefficients are generally smaller. These results suggest that monetary pass-through effect was even stronger during the financial crisis. This is not expected, due to the high credit premium in the Nibor rates during the financial crisis. However, given by the standard deviation in the estimation, the coefficients are probably not statistically different between the two periods.

Coefficients for the unpredicted monetary policy are close to 1. Generally, the Folio pass-through effect to the Nibor rates seems to be strong and robust.

Moreover, the variance in the residuals are constant in the 3-month Nibor model during the post-financial period. We also accept the null hypothesis in Jarque-Bera test. Residuals are normally distributed. As discussed in section 9.1, the financial crisis could be the origin for non-normal and heteroscedastic residuals. The robust standard errors are therefore replaced with OLS standard errors in the 3-month Nibor model.

Furthermore, the null hypothesis is accepted in the RESET, Breusch-Godfrey, White and Jarque-Bera tests. Results of statistical tests suggest that OLS is unbiased and BLUE.[41]

[41] All test statistics for the post-financial Nibor models are found in Appendix C, table; 66-73. Original outputs are visible in Appendix D, figure; 24 and 25.

9.6 Treasury Rates – after the financial crisis

Table 9: Regressions with 3-, 6-, and 12-month Treasury bill rates as dependent variables. Sample is collected between 19.10.2009 and 15.12.2016 (post financial crisis). In percent.

Independent variables	Treasury Bill 3-Month (Model 10)	Treasury Bill 6-Month (Model 11)	Treasury Bill 12-Month (Model 12)
$Intercept$	-0.002 (0.008)	-0.007 (0.006)	-0.001 (0.007)
$Expected_t$	-0.032 (0.085)	-0.106 (0.068)	0.001 (0.074)
$Unexpected_t$	0.595*** (0.112)	0,440*** (0.090)	0.519*** (0.098)
Observations	48	48	48
R^2	0.387	0.349	0.388
Adjusted R^2	0.360	0.320	0.361
F-statistics	14.230	12.085	14.302
P > F	0.000	0.000	0.000

Note: *, ** and *** Note: *, ** and *** represent coefficients, which are significantly different from zero. Respectively on a 0.1 (p<0.1), 0.05 (p<0.05) and 0,01 (p<0.01) percent level. Standard errors are displayed in brackets.

Regarding the Treasury Bill rates, all coefficients exhibiting the unexpected portion of the Folio rate decision are strongly significant and larger, compared to when the whole sample is estimated.

As asserted in section 5.5, the Government conducted unconventional market operations by issuing new Treasuries in the beginning of the financial crisis. Figure 14 displays how the supply of Treasuries increased by a considerable amount. It is assumed that the frequency of turnovers increased by a larger supply and demand for Treasuries after the financial crisis. This could explain why coefficients corresponding to the unexpected portion of the Folio rate is generally lager, and why the expected share of the Folio rate is small and insignificant in the post-financial crisis period.

Furthermore, the frequency in turnovers could be the explanation for the lack of serial correlated residuals in the 12-month treasury model.

Lastly, the null hypothesis is accepted in the RESET test, the Breusch-Godfrey test and the White-test. However, the Jarque-Bera tests results indicate that residuals are still not normally distributed. [42]

[42] All test statistics for the post-financial crisis Treasury models, are found in Appendix C, table; 74-90. Original outputs are visible in Appendix D, figure; 26 - 28.

9.7 The Bond Rates – After the Financial Crisis

Table 10: Regressions with 3-, 5- and 10-year Norwegian Bond interest rates as dependent variable. Sample is collected between 19.10.2009 and 15.12.2016 (post financial crisis). In percent.

Independent variables	5-Year Bond (Model 13)	10-Year Bond (Model 14)
Intercept	-0.001 (0.008)	0.002 (0.006)
$\boldsymbol{Expected_t}$	0.144* (0.084)	0.126* (0.016)
$\boldsymbol{Unexpected_t}$	0.163 (0.062)	0,047 (0.093)
5-*year EGB*	0.495*** (0.096)	Not Included
10-*year EGB*	Not Included	0,702*** (0.104)
Observations	48	48
R^2	0.311	0.528
Adjusted R^2	0.264	0.507
(Wald) F-statistics	6.631	(25.209)
P>F (Wald)	0.000	(0.000)

Note: *, ** and *** Note: *, ** and *** represent coefficients, which are significantly different from zero. Respectively on a 0.1 ($p<0.1$), 0.05 ($p<0.05$) and 0,01 ($p<0.01$) percent level. Robust standard errors are obtained with Newey-West estimators for the 10-year Bond model (7).

Firstly, reached results from the Bond models after the financial crsis indicate that the unexpected portion of the Folio rate has no significant impact on both Norwegian yields. The expected share of the Folio rate is significant for a 10 percent significance level. Therefore, these coefficients are considered as non-significant.

Furthermore, the 10-year Bond model contain heteroscedastic residuals. The residual plot suggests greater residuals in the end of the sample (Appendix E, figure 33). One explanation could be the sovereign debt crisis, which arose in the aftermath of the financial crisis.

As stated in section 4.6 and 4.7, Bernhardsen (2011) does not exclude that Norwegian securities are evaluated as "safe haven". This means that Norwegian securities are weighed as safer, compared to other securities. Typically, the demand for safe haven securities increase during economically turbulent periods. Ceteris paribus, larger demand increases the Bond prices, which pushes the interest rates down. Evjen, Grønvold and Gundersen (2017, Pp 16) also suggest that Norwegian Government Bonds seem to be more demanded when financial instability is present.

Accordingly, the Sovereign debt crisis could therefore be a contributor for a smaller Folio rate pass-through to Norwegian Bonds. Accordingly, the interest rate formation could rather be affected by fluctuations in the demand for Norwegian Bonds.

Moreover, the relationship between European yields and Norwegian yields is still large and highly significant. There results reinforce the impression that Norwegian expectations rely on the European economic outlook.

Finally, the null hypothesis is accepted for the Ramsey RESET test, the Breusch-Godfrey test and the Jarque-Bera test for both models. While residuals are independent given the explanatory variables in the 5-year model (6), heteroscedastic residuals are detected by the White test in the 10-year model (7). Robust standard residuals are therefore applied here.[43]

9.8 Limitations and Weakness in the Data

Related to the discussion in section 6.4, I do not exclude endogeneity possibilities in my models. However, the 3- and 6-month Nibor rate are not equivalent to the 1-month Nibor rate, which is used in the 1-month OIS estimate.

[43] All test statistics for the post-financial crisis Bond models, are found in Appendix C, table; 91-100. Original outputs are visible in Appendix D, figure; 29 - 30.

Moreover, the risk premium existing in the 1-, 3-, and 6-month Nibor rates contributes to the simultaneous bias. However, the premium is excluded in the 1-month OIS rate estimate. Without the premium present, a potential endogeneity factor is removed.

Furthermore, it is likely that other interest rates affect the Folio interest rates and therefore causing causality problems. However, the estimation is performed within a short time interval. Therefore, I am confident that the dependent variables react due to the unexpected and expected share of the Folio rate, and not the other way around.

The obtained OIS rate limits my sample period to approximately 10 years, between 24.01.2007 and 15.12.2016. Within the 10-year period there were 73 monetary meetings implemented. Due to the violated assumption discussed in section 8.3, we only include 72 observations in the sample. Two additional observations were removed in the Treasury models. It was assumed that these observations disrupted the average relationship between the Folio rate and the Treasury Bill.

Finally, as mentioned in 6.4, the estimated OIS rate is calculated as a moving average. Therefore, daily movements are unquestionably muted and regressions results can display weaker coefficients.

10. Concluding Remarks

My main results suggest that the expected share of the Folio interest rate have no impact for maturities less than 1 year, and unexpected adjustments in the Folio rate are highly significant for short-term interest rates.

The largest pass-through effect is registered in the Nibor rates. Coefficients estimated for the whole sample and the post-financial crisis period display values between 1.040 – 0.809 percent for the 3- and 6-month Nibor rates. Results indicate a strong and robust relationship between the Folio rate and the Nibor rates, which means that Norges Bank are capable to control the Nibor rate efficiently.

The pass-through effect to the Treasury rates are inferior, compared to the Nibor rates. One explanation can be an illiquid Treasury market. Results for the whole sample and post-financial crisis sample can support this view. Treasuries were the main instrument in unconventional policy and the pass-through effect is expected to be larger after the financial crisis.

Finally, results suggest that Norwegian Bonds are remarkable correlated with European Government Bonds. These findings suggest that the Norwegian economy is highly affected and dependent on the international economic environment. Therefore, the foreign economic outlook is of high interest. The impact from the Folio rate seems to be weaker. Norges Bank seems to have difficulties controlling long-term rates. Illiquid markets, combined with stochastic demand could be one reason.

Moreover, my results suggest that the Treasury rates and Bond rates can diverge from their fundamental price formation. According to economic theory, Folio rate adjustments should trigger reactions in both the short- and long-term. However, the expected portion of the Folio rate is significant for the 12-month Treasury Bill and the 10-year Bond over the entire sample period. After the subprime financial crisis, the supply of Treasuries was significantly increased and the expected portion of the Folio rate became insignificant for the 12-month Treasury Bill.

On the other hand, while the unexpected quantity of the Folio rate adjustment is significant for Government Bonds during the whole sample, the significance is lacking after the financial crisis. A larger demand for Norwegian Bonds during the debt crisis could be the explanation for the missing link between the Folio rate and the Bonds.

In order to have an effective market mechanisms operating, the liquidity must be improved. This should be a policy goal for the Government and the public institutions. Otherwise, the purchase and sale prices for these instruments may fluctuate excessively and depart from fundamental values. Accordingly, agents may require an additional liquidity premium to hold the security. Treasuries and Bonds might therefore not be suited to serve as a reference rates, which can further contribute to ineffective markets.

All results obtained share similarities to other comparable studies estimated in Sweden and the United States. The unexpected portion of the Folio rate is generally high and significant for short-term rates. The relationship between the Folio rate and long-term rates is equivalent for the whole sample, compared to other studies. To my knowledge, the outcomes of an insignificant Folio rate pass-through effect to Bonds, after the financial crisis is not confirmed or analysed by other studies before.

Regarding further research, since the Treasury and the Bond markets are illiquid, the observed time interval for these rates can be expanded. By including observed fluctuations 4 to 5 days after a monetary announcement, a lagged response in these securities can be caught.

11. References

Aamodt. E. & Tafjord. K. 2013. Structural Liquidity. ***Economic commentaries***. No 9, Norges Bank

Bernhardsen. T. & Røsland, Ø. 2000. Hva påvirker kronekursen? ***Penger og Kreditt.*** No 03/2000. Norges Bank

Bernhardsen. T. 2011. Renteanalysen. ***Staff Memo***. Nr. 04. Norges Bank

Bernhardsen. T. 2012, Sammenhengen mellom styringsrenten og pengemarkedsrentene: 2007-2012. ***Aktuell kommentar.*** No. 2. Norges Bank

Bernhardsen, T., Kloster, A., & Syrstad, O. 2012. Risikopåslagene I Nibor and lands interbankrenter. ***Staff Memo*** Nr. 20. Norges Bank

Claussen. C., A. Jonassen. M. & Langbraaten. N. 2007. Ordningen for pengepolitikk. Norges Bank I lys av litteraturen og internasjonal praksis**. *Economic Bulletin.*** 4/2007.

Cook. T. & Hahn. T. 1988. ***The effect of changes in the federal funds rate target on market interests in the 1970s***, Working Paper 88-4. Federal Reserve Bank of Richmond.

Corder & Foreman, 2009, ***Nonparametric statistics for non-statisticians: a step-by-step approach***, p.2; footnote No 1, John Wiley & Sons, Inc. Hoboken, New Jersey.

Eeg. K, 2007. Hvordan påvirkes norske markedsrenter av økonomiske nyheter? ***Penger og Kreditt.*** 4/2007. Norges Bank

El-Salam, M., EF., A. 2013. A modification of the Jarque-Bera test for normality. ***International journal of contemporary mathematical sciences.*** Vol 8. No 17. 843-853

Evjen., S. Grønvold., M. Gundersen., K. 2017. Liquidity in the Norwegian Government bond market. ***Norges Bank Staff Memo.*** No 1. Norges Bank.

Fawley. B., W. & Neely. C., J. 2014. The Evolution of Federal Reserve Policy and the Impact of Monetary Policy Surprises on Asset Prices. ***Federal Reserve Bank of St. Louis Review.*** Vol 96. Issue 1. Pp 73-109

Fransson, L. & Tysklind, O. 2016. The effects of monetary policy on interest rates. ***Sveriges Riksbank Economic Review***. No.1

Fung, A. & Chapple, B. 1994. The yield curve as an indicator on monetary conditions. ***Reserve Bank Bulletin vol. 57. No 1***

Goldberg. L & Leonard. D. 2003. What Moves Sovereign Bond Markets? The Effects of Economic News on U.S. and German Yields. ***Current issues in economics and finance volume 9,*** No 9, Federal Reserve Bank of New York

Haare., L. & Solheim. 2014. Norges Banks rolle på finanssektorområdet i perioden 1945-2013, med særlig vekt på finansiell stabilitet. ***Norges Bank Occasional Papers.*** No 48. Norges Bank.

Hellum, Erlend and Kårvik, Geir-Are Ø., 2012. ***Economic commentaries.*** No. 5. 2012. Norges Bank

Jarrow, R., A.1981. Liquidity premiums and the expectation hypothesis. ***Journal of banking and finance***. No 5. pp 539-546

Kran, L., C & Øwre. G. Norges Bank system for å styre renten. ***Penger og kreditt.*** 0/1-2001. Norges Bank.

Kloster, A. 2000. Beregning og tolkning av renteforventninger. ***Economic commentaries.*** No 01/2000.

Kuttner, K., N. 2001. Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market. ***Journal of Monetary Economics***. Volume 47, Issue 3. Pp 523-544.

Kydland, F., E., & Prescott, E., C. 1977. Rules rather than discretion: The inconsistency of optimal plans. ***Journal of Political Economy***. Vol 85. No 3.

Myklebust, G. 2005. Risikopremier i det norske rentemarkedet. ***Penger og Kreditt***. No 3/2005. Norges Bank

Myklebust, G. 2005. Documentation of the method used by Norges Bank for estimating implied forward interest rates. ***Staff Memo***. No 2005/11. Norges Bank

Natvik. G. & Sauvik. L. 2013. Forventingsdrevet gjeldskrise og mottiltak, ***Staff Memo.*** No 7, Norges Bank

Norges Bank. 2017, Norway's finacial system – An overview. ***Norway's finacial system***. No 2017.

Norges Bank. 2004. Norske finansmarkeder – Pengepolitikk og finasiell stabilitet. ***Occasional papers***. No 34, Norges Bank

Norges Bank, 2010, ***Årsmelding og regnskap***. Norges Bank

Rakkestad, K., J. & Hein., J., B. 2004. Om langsiktige referanserenter I det norske obligasjonsmarkedet. ***Penger og kreditt***. No. 3/2004. Norges Bank

Roley, V., V. & Sellon, G., H. 1995. Monetary Policy Actions and Long Term Interest Rates». ***Economic Quarterly***. 80(4), 77– 89. Federal Reserve Bank of Kansas City

Soikkeli, J. 2002. The inflation targeting framework in Norway. ***IMF working paper.*** NO 02/184

Steigum, E. 2006. ***Moderne makroøkonomi.*** (5th edition). Pp 454 – 532, 170-172, 350-353, Pp 441. Gyldendal Akademiske; Oslo, Norway.

Valseth, S. 2003. Renteforventninger og betydningen av løpetidspremier. ***Economic commentaries***. No 03/2003. Norges Bank

Woodford, M. 2003. ***Interest and Prices: Foundations of a Theory of Monetary Policy.*** Pp 14-17. Princeton University Press.

Wooldridge, J. M. 2013. ***Introductory Econometrics: A Modern Approach (Fifth international ed.)***. Pp. 82–84, 258-263, 343-345, 296-302, 383-385, 370, 368-372, 408, 316-321, 618, 854. Michigan State University. Australia: South-Western.

11.1 Web pages

Andersen, T., Q. & Lydersen, T., 2007. Gjedrem hever renten. E24.no. retrieved from: http://e24.no/makro-og-politikk/gjedrem-hever-renten/2015756

Brander, A., S. 26.09.2011. Kutter renten til 1,75 prosent. E24.no. retrieved from: http://e24.no/makro-og-politikk/kutter-renten-til-1-75-prosent/20131458

F-lån, Norges bank, retrieved from; http://www.norges-bank.no/Bank-og-marked/Sikkerhet-for-bankenes-lan/Om-sikkerhet-for-lan/

F-lån, fixed interest, 2008, "Norges bank Publications", retrieved from; http://www.norges-bank.no/Bank-og-marked/Markedsoperasjoner/F-lan-og-F-innskudd/

Fidjestøl, Asbjørn, 2007, "Sentralbankens likviditetspolitikk i en oljeøkonomi", Norges bank publications; Money and credit 03/2007, retrieved from; http://www.norges-bank.no/Upload/63525/sentralbankens_likvisitetspolitikk.pdf

Nobelprize.org. 2004. The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2004», Nobel Media AB 2014. Web. 3 Oct 2017, Retrived from; https://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2004/

Norges Bank, 2016, «Quotas in the system for management of bank reserves», Norges-bank-no, retrieved from; http://www.norges-bank.no/en/Published/Circulars/2016/6-Quotas-in-the-system-for-the-management-of-bank-reserves/

Norges Bank, 2008, «Norges Bank will assess interest rate at executive board meeting on 15th October», Norges-bank.no, retrieved from; http://www.norges-bank.no/en/Published/Press-releases/2008/Norges-Bank-will-assess-interest-rate-at-Executive-Board-meeting-on-15-October/

Norges Bank, 2016, kvote på innskuddskonto I Norges bank; http://www.norges-bank.no/Publisert/Rundskriv/2016/6-Kvoter-i-systemet-for-styring-av-bankenes-reserver/

Norway, Ministry of finance, 2001, Storting report No. 29. The financial supervisory authority of Norway, 2016, retrieved from; http://www.finanstilsynet.no/no/Artikkelarkiv/Aktuelt/2015/4_kvartal/Bankenes-kapitalkrav/

Oslo Stock exchange. 2017. Opening Hours. Retrieved from;
https://www.oslobors.no/ob_eng/Oslo-Boers/About-Oslo-Boers/Opening-hours

Obligasjoner, Norske Børs, retrieved from;
file:///Users/oskarhjorth/Downloads/Obligasjonsbrosjyre_2007%20(2).pdf

Parr, O., S. 2012. Rentesjokk!. Hegnar.no. retrieved from:
http://www.hegnar.no/Nyheter/Naeringsliv/2012/03/Rentesjokk

Sonigara. Kush, 2012, «typed and shifts in a yield curve», Fixed income Indida, retrieved from; https://kbsonigara.wordpress.com/2012/08/02/types-and-shifts-in-a-yield-curve/

Takla, E. 2016. Nå går Norges viktigste renter hver sin vei. Dagens Næringsliv, Retrieved from: http://www.dn.no/nyheter/okonomi/2016/08/20/1456/n-gr-norges-viktigste-renter-hver-sin-vei

Tradingeconomics.com. 2017. Norwegian Treasury credit rating history. Retrieved from;
https://tradingeconomics.com/norway/rating

I. Appendix

12. Appendix A

12.1 Interest Rate Series

Note: t represent the Folio interest rate announcement day. Hence, $t-1$ is the day, prior to the announcement.

Table 12: The expected and unexpected portion of the Folio interest rates

Variable	Series	Measure	Definition	Link
Expected	The expected portion of the Folio rate decision 72 observations between 2007M1 – 2016m12	$\Delta r_t^E = \Delta r_t^{Folio} - \Delta r_t^U$ In percentage points. Daily changes between the Folio announcement day and the day prior to the announcement. See section (defining the OIS rate)	The variable is representing expectations for the forthcoming Folio interest rate. The variable is defined by the difference between the actual Folio rate change and the unexpected share of the Folio rate change.	Obtained by mail from Norges Bank the 24.07.17. Combination of obtained data by mail from Norges Bank the 24.07.17. And: http://www.norges-bank.no/en/Statistics/Interest-rates/
Unexpected	The unexpected portion of the Folio rate decision 72 observations between 2007M1 – 2016m12	$\Delta r_t^U = OIS_t^{1\,Month} - OIS_{t-1}^{1\,Month}$ In percentage points. Daily changes between the Folio announcement day and the day prior to the announcement. See section (defining the OIS rate)	The variable is representing unexpected changes in the Folio. The variable is calculated as the difference between the OIS rate on the Folio announcement day and the day prior to the announcement.	Obtained by mail from Norges Bank the 24.07.17. For further information, send mail to Oskar0911@gmail.com

Table 13: The Nibor interest rates

Variable	Series	Measure	Definition	Link
3-Month Nibor interest rate	The 3-month Nibor rate. 72 observations between 2007M1 – 2016m12	$\Delta 3\ Month\ Nibor_t = 3M\ Nibor_t - 3M\ Nibor_{t-1}$ In percentage points.	Measure the difference in percentage points in the 3-month Nibor rate between the Folio rate announcement day and the day prior	Norges Bank (2007M1-2013M12: http://www.norges-bank.no/en/Statistics /Historical-monetary-statistics/Short-term-interest-rates/ Oslo Stock exchange (2014M1-2016M12): https://www.oslobors.no/ markedsaktivitet/#/details/ NIBOR3M.NIBOR/overview
6-Month Nibor interest rate	The 6-month Nibor rate. 72 observations between 2007M1 – 2016m12	$\Delta 6\ Month\ Nibor_t = 6M\ Nibor_t - 6M\ Nibor_{t-1}$ In percentage points.	Measure the difference in percentage points in the 6-month Nibor rate between the Folio rate announcement day and the day prior	Norges Bank (2007M1-2013M12: http://www.norges-bank.no/en/Statistics /Historical-monetary-statistics/Short-term-interest-rates/ Oslo Stock exchange (2014M1-2016M12): https://www.oslobors.no/ markedsaktivitet/#/details/ NIBOR3M.NIBOR/overview

Table 14: The Government Treasury rates

Variable	Series	Measure	Definition	Link
3-Month government treasury rate	The 3-month government treasury rate. 72 observations between 2007M1 – 2016m12	$\Delta 3\ Month\ Treasury_t = 3M\ Treasury_t - 3M\ Treasury_{t-1}$ In percentage points.	Measure the difference in percentage points in the 3-month government treasury rate between the Folio rate announcement day and the day prior	http://www.norges-bank.no/en/Statistics/Interest-rates/
6-Month government treasury rate	The 6-month government treasury rate. 72 observations between 2007M1 – 2016m12	$\Delta 6\ Month\ Treasury_t = 6M\ Treasury_t - 6M\ Treasury_{t-1}$ In percentage points.	Measure the difference in percentage points in the 6-month government treasury rate between the Folio rate announcement day and the day prior	http://www.norges-bank.no/en/Statistics/Interest-rates/
12-Month government treasury rate	The 12-month government treasury rate. 72 observations between 2007M1 – 2016m12	$\Delta 12\ Month\ Treasury_t = 12M\ Treasury_t - 12M\ Treasury_{t-1}$ In percentage points.	Measure the difference in percentage points in the 12-month government treasury rate between the Folio rate announcement day and the day prior	http://www.norges-bank.no/en/Statistics/Interest-rates/

Table 15: The Government Bond rates

Variable	Series	Measure	Definition	Link
5-year government bond rate	5-year government bond rate. 72 observations between 2007M1 – 2016m12	$\Delta 5\ Year\ Bond_t = 5\ Year\ Bond_t - 5\ Year\ Bond_{t-1}$ In percentage points.	Measure the difference in percentage points in the 5-year government bond rate between the Folio rate announcement day and the day prior	http://www.norges-bank.no/en/Statistics/Interest-rates/
10-year government bond rate	10-year government bond rate. 72 observations between 2007M1 – 2016m12	$\Delta 10\ Year\ Bond_t = 10\ Year\ Bond_t - 10\ Year\ Bond_{t-1}$ In percentage points.	Measure the difference in percentage points in the 10-year government bond rate between the Folio rate announcement day and the day prior	http://www.norges-bank.no/en/Statistics/Interest-rates/

Table 16: The European Government Bond rates

Variable	Series	Measure	Definition	Link
5-year European government bond rate	5-year European government bond rate. 72 observations between 2007M1 – 2016m12	$\Delta 5\ Year\ EGB\ Bond_t = 5\ Year\ EGB\ Bond_t - 5\ Year\ EGB\ Bond_{t-1}$ In percentage points.	Measure the difference in percentage points in the 5-year European government bond rate between the Folio rate announcement day and the day prior	http://www.riksbank.se/en/Interest-and-exchange-rates/search-interest-rates-exchange-rates/?g99-EMGVB5Y=on&g100-EMGVB10Y=on&from=2006-02-01&to=2017-10-20&f=Day&cAverage=Average&s=Comma#search
10-year European government bond rate	10-year European government bond rate. 72 observations between 2007M1 – 2016m12	$\Delta 10\ Year\ EGB\ Bond_t = 10\ Year\ EGB\ Bond_t - 10\ Year\ EGB\ Bond_{t-1}$ In percentage points.	Measure the difference in percentage points in the 10-year European government bond rate between the Folio rate announcement day and the day prior	http://www.riksbank.se/en/Interest-and-exchange-rates/search-interest-rates-exchange-rates/?g99-EMGVB5Y =on&g100-EMGVB10Y=on&from=2006-02-01&to=2017-10-20&f=Day&cAverage=Average&s=Comma#search

13. Appendix B

13.1 Explanatory variables analysis

Table 17: Unit Root Augmented Dickey-Fuller test statistic for Unexpected Folio rate change. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. (72 observations)

Null Hypothesis: UNEXPECTED has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 1 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-8.026759	0.0000
Test critical values:	1% level		-4.094550	
	5% level		-3.475305	
	10% level		-3.165046	
*MacKinnon (1996) one-sided p-values.				

Table 18: Unit Root Augmented Dickey-Fuller test statistic for Unexpected Folio rate change. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(70 observations)**

Null Hypothesis: UNEXPECTED has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=10)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-9.486611	0.0000
Test critical values:	1% level		-4.096614	
	5% level		-3.476275	
	10% level		-3.165610	
*MacKinnon (1996) one-sided p-values.				

Table 19: Unit Root Augmented Dickey-Fuller test statistic for Expected Folio rate change. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented.

(72 observations)

Null Hypothesis: EXPECTED has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 3 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.931222	0.0159
Test critical values:	1% level		-4.098741	
	5% level		-3.477275	
	10% level		-3.166190	
*MacKinnon (1996) one-sided p-values.				

Table 20: Unit Root Augmented Dickey-Fuller test statistic for Expected Folio rate change. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented.

(70 observations)

Null Hypothesis: EXPECTED has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=10)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.294401	0.0057
Test critical values:	1% level		-4.096614	
	5% level		-3.476275	
	10% level		-3.165610	
*MacKinnon (1996) one-sided p-values.				

Table 21: Unit Root Augmented Dickey-Fuller test statistic for 5-year European Government Bond. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(72 observations)**

Null Hypothesis: EGB5Y has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-8.723723	0.0000
Test critical values:	1% level		-4.092547	
	5% level		-3.474363	
	10% level		-3.164499	
*MacKinnon (1996) one-sided p-values.				

Table 22: Unit Root Augmented Dickey-Fuller test statistic for 10-year European Government Bond. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(72 observations)**

Null Hypothesis: EGB10Y has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-9.150104	0.0000
Test critical values:	1% level		-4.092547	
	5% level		-3.474363	
	10% level		-3.164499	
*MacKinnon (1996) one-sided p-values.				

13.2 Explained variable analysis

Unit root tests for explained variables

Table 23: Unit Root Augmented Dickey-Fuller test statistic for 3-month Nibor interest rate. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(72 observations)**

Null Hypothesis: NIBOR3M has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-11.30474	0.0000
Test critical values:	1% level		-4.092547	
	5% level		-3.474363	
	10% level		-3.164499	
*MacKinnon (1996) one-sided p-values.				

Table 24: Unit Root Augmented Dickey-Fuller test statistic for 6-month Nibor interest rate. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(72 observations)**

Null Hypothesis: NIBOR6M has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-12.88772	0.0001
Test critical values:	1% level		-4.092547	
	5% level		-3.474363	
	10% level		-3.164499	
*MacKinnon (1996) one-sided p-values.				

Table 25: Unit Root Augmented Dickey-Fuller test statistic for 3-month Government Treasury bill Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(70 observations)**

Null Hypothesis: TBILL3M has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=10)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-8.510019	0.0000
Test critical values:	1% level		-4.096614	
	5% level		-3.476275	
	10% level		-3.165610	
*MacKinnon (1996) one-sided p-values.				

Table 26: Unit Root Augmented Dickey-Fuller test statistic for 6-month Government Treasury bill Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(70 observations)**

Null Hypothesis: TBILL6M has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=10)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-8.995509	0.0000
Test critical values:	1% level		-4.096614	
	5% level		-3.476275	
	10% level		-3.165610	
*MacKinnon (1996) one-sided p-values.				

Table 27: Unit Root Augmented Dickey-Fuller test statistic for 12-month Government Treasury bill Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(70 observations)**

Null Hypothesis: TBILL12M has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=10)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-8.447468	0.0000
Test critical values:	1% level		-4.096614	
	5% level		-3.476275	
	10% level		-3.165610	
*MacKinnon (1996) one-sided p-values.				

Table 28: Unit Root Augmented Dickey-Fuller test statistic for 5-year Government Bond Intercept + Trend are included in the equation. Akaike Info Criterion is implemented. **(72 observations)**

Null Hypothesis: BOND5Y has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 5 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.638907	0.0340
Test critical values:	1% level		-4.103198	
	5% level		-3.479367	
	10% level		-3.167404	
*MacKinnon (1996) one-sided p-values.				

Table 29: Unit Root Augmented Dickey-Fuller test statistic for 10-year Government Bond. Intercept + Trend are included in the equation. Akaike Info Criterion is implemented.

(72 observations)

Null Hypothesis: BOND10Y has a unit root				
Exogenous: Constant, Linear Trend				
Lag Length: 0 (Automatic - based on AIC, maxlag=11)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-9.618740	0.0000
Test critical values:	1% level		-4.092547	
	5% level		-3.474363	
	10% level		-3.164499	
*MacKinnon (1996) one-sided p-values.				

13.3 Correlation Matrix

Table 30: Correlation matrix. All variables are included in the matrix. Note: the correlation between the 5- and 10-year European bond is high. However, these independent variables are never combined in the conducted regressions.

Correlation Matrix

	NIBOR3M	NIBOR6M	BILL_3M	BILL_6M	BILL_12M	BOND10Y	BOND5Y	EU10Y	EU5Y	EXP1M	UNEX1M
NIBOR3M	1.000000	0.926046	0.527548	0.734936	0.648227	0.357805	0.451950	0.169289	0.111058	0.277796	0.900599
NIBOR6M	0.926046	1.000000	0.426572	0.616001	0.680725	0.344249	0.490341	0.144088	0.092667	0.194172	0.843576
BILL_3M	0.527548	0.426572	1.000000	0.817788	0.226249	0.241134	0.283508	0.170445	0.134256	-0.087013	0.320243
BILL_6M	0.734936	0.616001	0.817788	1.000000	0.476234	0.358739	0.486548	0.180350	0.137065	0.123703	0.544543
BILL_12M	0.648227	0.680725	0.226249	0.476234	1.000000	0.319538	0.483591	0.061316	0.047009	0.557491	0.599004
BOND10Y	0.357805	0.344249	0.241134	0.358739	0.319538	1.000000	0.888439	0.731140	0.676601	0.339189	0.347538
BOND5Y	0.451950	0.490341	0.283508	0.486548	0.483591	0.888439	1.000000	0.552363	0.506551	0.340531	0.414641
EU10Y	0.169289	0.144088	0.170445	0.180350	0.061316	0.731140	0.552363	1.000000	0.902749	0.199816	0.210836
EU5Y	0.111058	0.092667	0.134256	0.137065	0.047009	0.676601	0.506551	0.902749	1.000000	0.199850	0.179695
EXP1M	0.277796	0.194172	-0.087013	0.123703	0.557491	0.339189	0.340531	0.199816	0.199850	1.000000	0.248473
UNEX1M	0.900599	0.843576	0.320243	0.544543	0.599004	0.347538	0.414641	0.210836	0.179695	0.248473	1.000000

14. Appendix C

14.1 Model estimation

In total has 7 models been estimated. However, every model is estimated for two different periods. The first 7 models presented here, include all monetary meetings from 24th og January 2007 to 15th of December 2017. While the last 7 models are estimated from 28th of October 2009 to 15th of December 2017. Here I present the Ramsey RESET test to test the functional form of all the models. The null hypothesis and the alternative hypothesis is as follows:

$$H_0 = Functional\ form\ well\ specified$$
$$H_1 = Functional\ form\ is\ misspesified$$

Furthermore, the Breusch-Godfrey serial correlation LM test is applied, in order to detect autocorrelation problems. The null hypothesis and the alternative hypothesis is as follows:

$$H_0 = \ No\ serial\ correlation\ in\ the\ residuals$$
$$H_1 = Serial\ correlation\ in\ the\ residuals$$

The White test is conducted to detect potential heteroscedasticity problems in the models. The null hypothesis and the alternative hypothesis is as follows:

$$H_0 = \ Homoscedastic\ residuals$$
$$H_1 = Heteroscedastic\ residuals$$

Finally, the Jarque-Bera test is whether the residuals are normally distributed, or not. The null hypothesis and the alternative hypothesis is as follows:

$$H_0 = \ Normality\ of\ residuals$$
$$H_1 = Non\text{-}normality\ of\ residuals$$

Variance inflation factors for all models are presented with associated model. Values below 10 indicate no perfect relationship between the explanatory variables (Wooldridge, 2013, Pp: 94).

Note: The models are numerated according to their numbers in the text. In order to save space have I only included the test statistics from all tests.

14.2 Stability, Coefficient and Residuals statistics for estimated models.

The entire sample is included: 72 observations (Treasury models includes 70 observations).

Model 1: $\Delta 3\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Table 31: The Ramsey RESET test for model 1

Ramsey RESET Test			
Equation: UNTITLED			
Specification: NIBOR3M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	1.240687	68	0.2190
F-statistic	1.539303	(1, 68)	0.2190
Likelihood rati	1.611677	1	0.2043

Table 32: Breusch-Godfrey autocorrelation test for model 1

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	1.012460	Prob. F(2,67)		0.3688
Obs*R-square	2.112197	Prob. Chi-Square(2)		0.3478

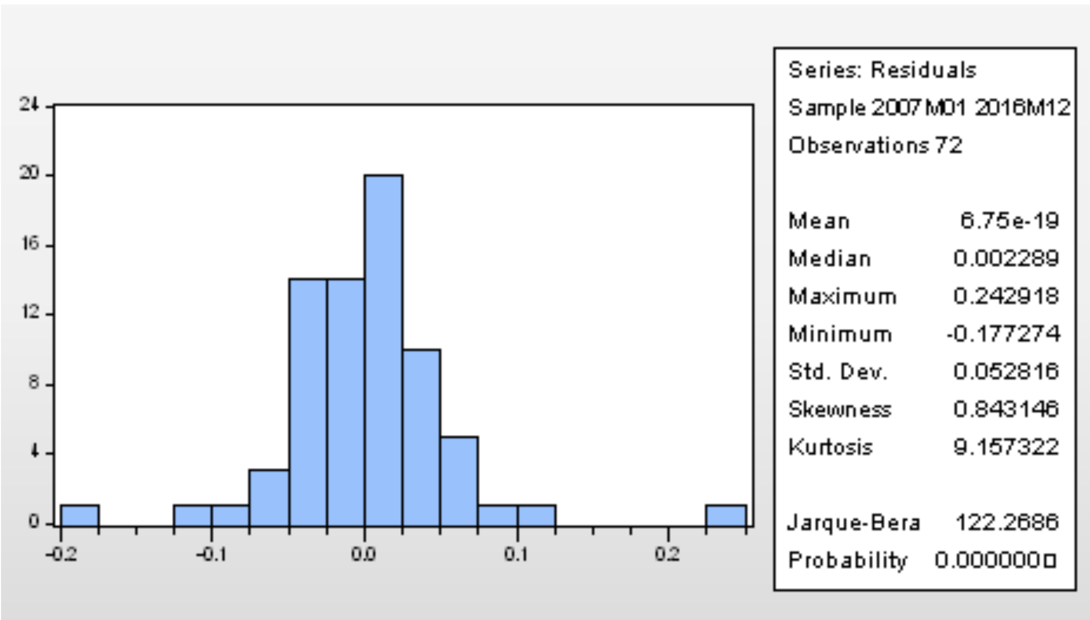
Table 33: The White test for model 1

Heteroskedasticity Test: White			
F-statistic	6.795663	Prob. F(5,66)	0.0000
Obs*R-square	24.46969	Prob. Chi-Square(5)	0.0002

Table 34: Variance Inflation factors (VIF) in model 1

Variance Inflation Factors			
Date: 10/18/17 Time: 17:51			
Sample: 2007M01 2016M12			
Included observations: 72			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXPECTED	0.001360	1.615965	1.615947
UNEXPECTED	0.005358	1.671246	1.615947
C	2.53E-05	1.056553	NA

Table 35: Histogram and Jarque-Bera test of residuals in model 1



Model 2: $\Delta 6\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(72 observations)

Table 36: The Ramsey RESET test for model 2

Ramsey RESET Test			
Equation: UNTITLED			
Specification: NIBOR6M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.210904	68	0.8336
F-statistic	0.044480	(1, 68)	0.8336
Likelihood rati	0.047081	1	0.8282

Table 37: Breusch-Godfrey autocorrelation test for model 2

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	2.732971	Prob. F(2,67)	0.0723
Obs*R-square	5.430797	Prob. Chi-Square(2)	0.0662

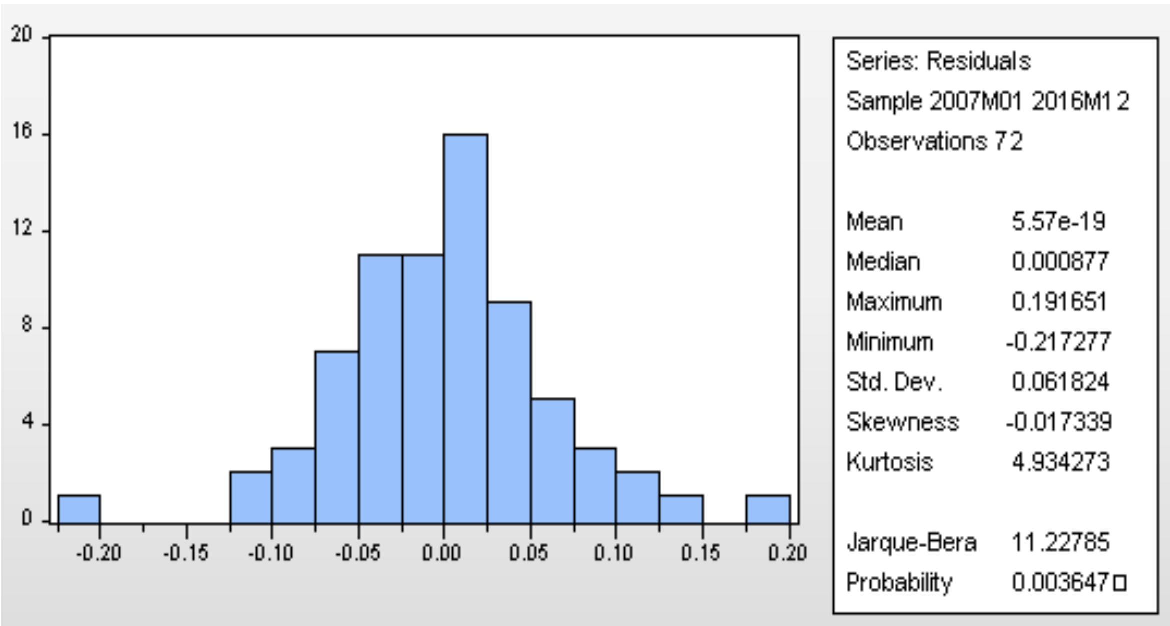
Table 38: The White test for model 2

Heteroskedasticity Test: White			
F-statistic	1.813270	Prob. F(5,66)	0.1223
Obs*R-square	8.696004	Prob. Chi-Square(5)	0.1218

Table 39: Variance Inflation factors (VIF) in model 2

Variance Inflation Factors			
Date: 10/18/17 Time: 18:36			
Sample: 2007M01 2016M12			
Included observations: 72			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXPECTED	0.001095	1.093470	1.065801
UNEXPECTED	0.005421	1.065908	1.065801
C	5.61E-05	1.026920	NA

Table 40: Histogram and Jarque-Bera test for residuals in model 2



Model 3: $\Delta 3\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(70 observations)

Table 41: The Ramsey RESET test for model 3

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BILL_3M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	1.457337	66	0.1498
F-statistic	2.123831	(1, 66)	0.1498
Likelihood rati	2.217065	1	0.1365

Table 42: Breusch-Godfrey autocorrelation test for model 3

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	0.689454	Prob. F(2,65)		0.5055
Obs*R-square	1.454131	Prob. Chi-Square(2)		0.4833

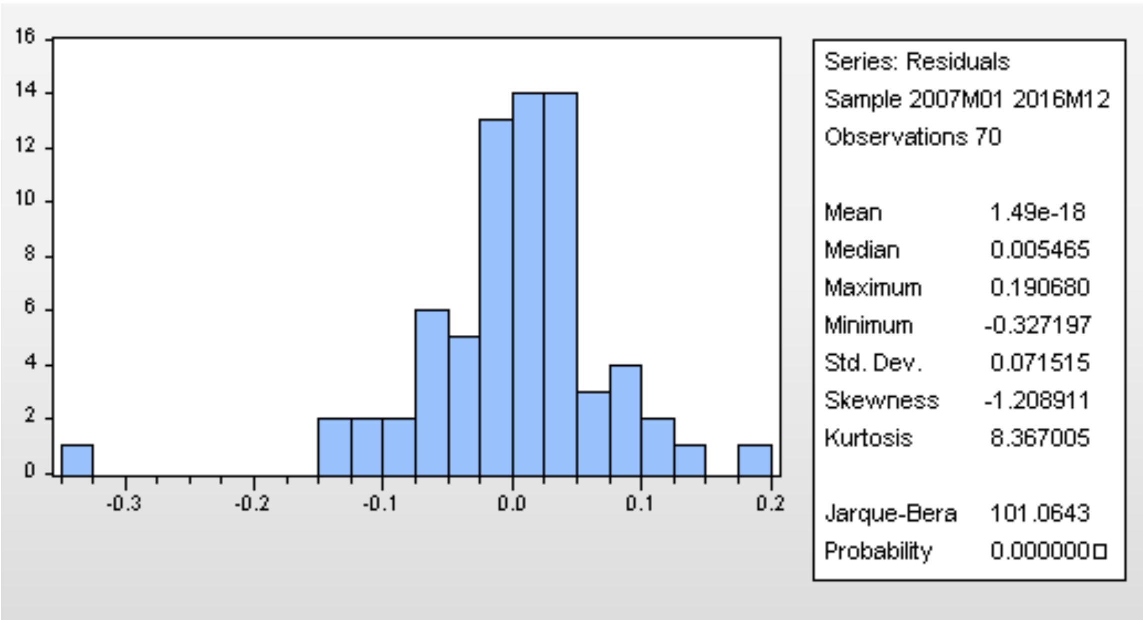
Table 43: The White test for model 3

Heteroskedasticity Test: White			
F-statistic	0.587936	Prob. F(5,64)	0.7091
Obs*R-square	3.074074	Prob. Chi-Square(5)	0.6886
Scaled explain	10.37358	Prob. Chi-Square(5)	0.0653

Table 44: Variance Inflation factors (VIF) in model 3

Variance Inflation Factors			
Date: 10/18/17 Time: 18:57			
Sample: 2007M01 2016M12			
Included observations: 70			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXPECTED	0.001756	1.160357	1.144602
UNEXPECTED	0.008583	1.148928	1.144602
C	7.63E-05	1.014212	NA

Table 45: Histogram and Jarque-Bera test for residuals in model 3



Model 4: $\Delta 6\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(70 observations)

Table 46: Ramsey RESET test for model 4

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BILL_6M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.437673	66	0.6631
F-statistic	0.191558	(1, 66)	0.6631
Likelihood rati	0.202873	1	0.6524

Table 47: Breusch-Godfrey autocorrelation test for model 4

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	1.333123	Prob. F(2,65)		0.2708
Obs*R-square	2.758202	Prob. Chi-Square(2)		0.2518

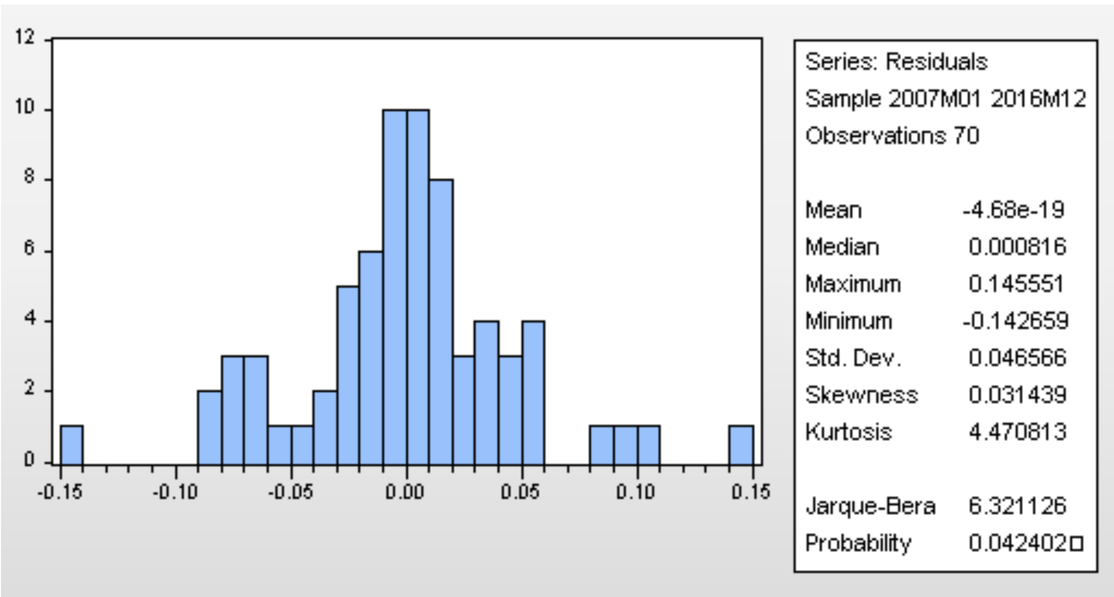
Table 48: The White test for model 4

Heteroskedasticity Test: White				
F-statistic	0.420142	Prob. F(5,64)		0.8330
Obs*R-square	2.224633	Prob. Chi-Square(5)		0.8173
Scaled explain	3.536821	Prob. Chi-Square(5)		0.6178

Table 49: Variance inflation factors in model 4

Variance Inflation Factors			
Date: 10/18/17 Time: 18:58			
Sample: 2007M01 2016M12			
Included observations: 70			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXPECTED	0.000744	1.160357	1.144602
UNEXPECTED	0.003639	1.148928	1.144602
C	3.24E-05	1.014212	NA

Table 50: Histogram and Jarque-Bera test for residuals in model 4



Model 5: $\Delta 12\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(70 observations)

Table 51: The Ramsey RESET test for model 5

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BILL_12M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.215560	66	0.8300
F-statistic	0.046466	(1, 66)	0.8300
Likelihood rat	0.049265	1	0.8243

Table 52: Breusch-Godfrey autocorrelation test for model 5

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	3.904230	Prob. F(2,65)		0.0250
Obs*R-square	7.507262	Prob. Chi-Square(2)		0.0234

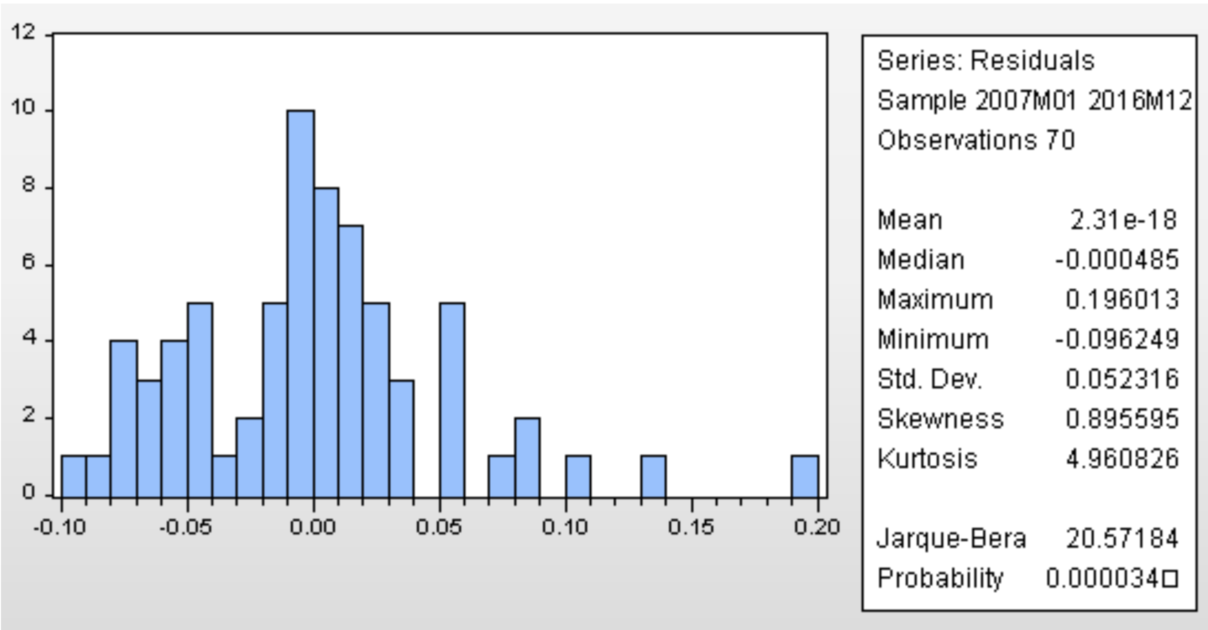
Table 53: The White test for model 5

Heteroskedasticity Test: White			
F-statistic	0.062016	Prob. F(5,64)	0.9973
Obs*R-square	0.337514	Prob. Chi-Square(5)	0.9969
Scaled explain	0.612352	Prob. Chi-Square(5)	0.9874

Table 54: Variance inflation factors for model 5

Variance Inflation Factors			
Date: 10/18/17 Time: 19:00			
Sample: 2007M01 2016M12			
Included observations: 70			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXPECTED	0.000862	2.175241	2.173162
UNEXPECTED	0.004910	2.297093	2.173162
C	2.07E-05	1.102421	NA

Table 55: Histogram and Jarque-Bera test for residuals in model 5



Model 6: $\Delta 5\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 5\ year\ EGB_t + \varepsilon_t$, (72 observations)

Table 56: The Ramsey RESET test for model 6

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BOND5Y EXP1M UNEX1M EU5Y C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.031216	67	0.9752
F-statistic	0.000974	(1, 67)	0.9752
Likelihood rat	0.001047	1	0.9742

Table 57: Breusch-Godfrey autocorrelation test for model 6

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.273344	Prob. F(2,66)	0.7617
Obs*R-square	0.591487	Prob. Chi-Square(2)	0.7440

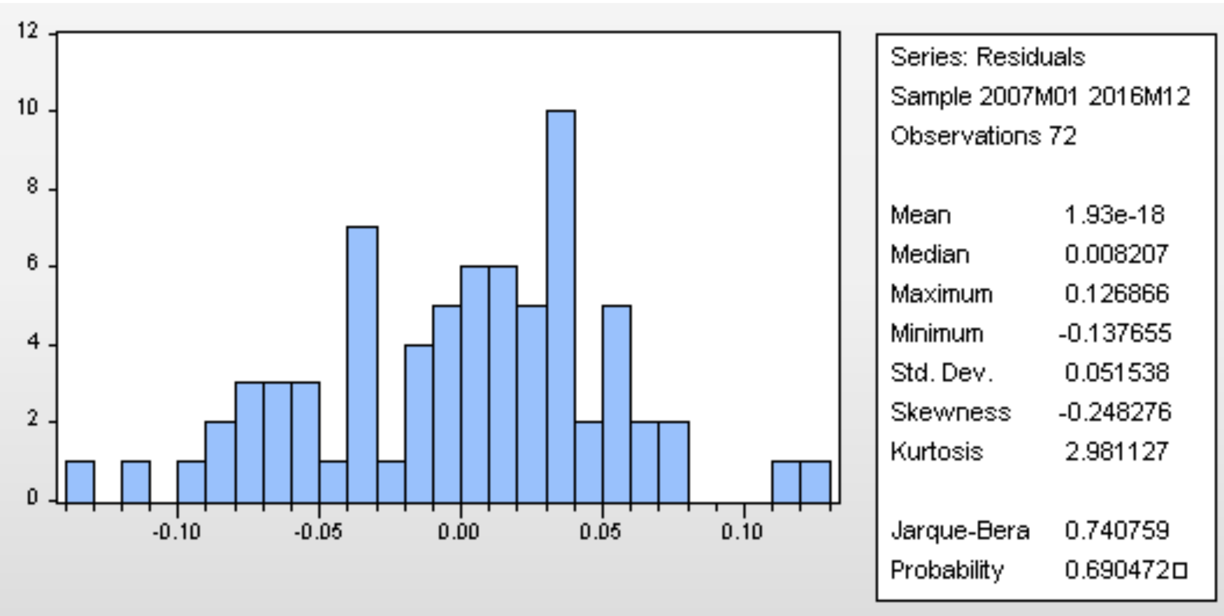
Table 58: The White test for model 6

Heteroskedasticity Test: White			
F-statistic	0.796653	Prob. F(9,62)	0.6206
Obs*R-square	7.463234	Prob. Chi-Square(9)	0.5890
Scaled explain	6.594201	Prob. Chi-Square(9)	0.6793

Table 59: Variance inflation factors in model 6

Variance Inflation Factors			
Date: 10/18/17 Time: 18:43			
Sample: 2007M01 2016M12			
Included observations: 72			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXPECTED	0.000793	1.123269	1.094846
UNEXPECTED	0.003896	1.086301	1.086192
EU5Y	0.009230	1.076024	1.061529
C	3.99E-05	1.035294	NA

Table 60: Histogram and Jarque-Bera test for residuals in model 6



Model 7: $\Delta 10\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 10\ year\ EGB_t + \varepsilon_t$, (72 observations)

Table 61: The Ramsey RESET test for model 7

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BOND10Y EXP1M UNEX1M EU10Y C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.325804	67	0.7456
F-statistic	0.106148	(1, 67)	0.7456
Likelihood rat	0.113980	1	0.7357

Table 62: Breusch-Godfrey autocorrelation test for model 7

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.157778	Prob. F(2,66)	0.8544
Obs*R-square	0.342604	Prob. Chi-Square(2)	0.8426

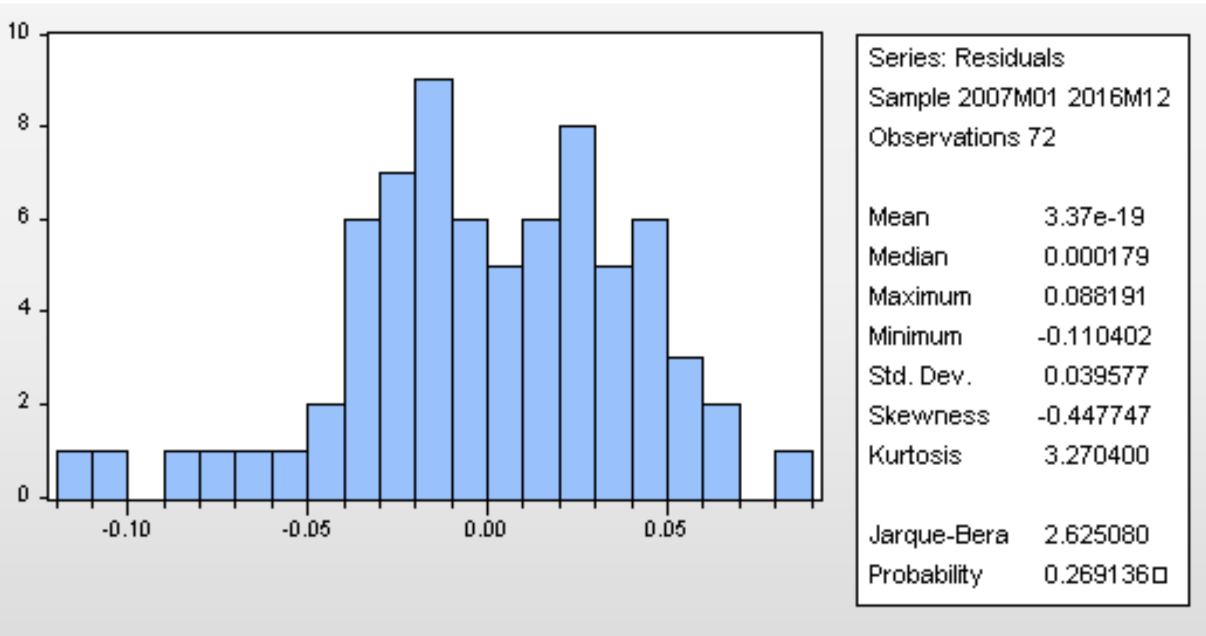
Table 63: The White test for model 7

Heteroskedasticity Test: White			
F-statistic	2.418819	Prob. F(9,62)	0.0201
Obs*R-square	18.71084	Prob. Chi-Square(9)	0.0278
Scaled explain	18.94604	Prob. Chi-Square(9)	0.0257

Table 64: Variance inflation factors in model 7

Variance Inflation Factors			
Date: 10/18/17 Time: 18:47			
Sample: 2007M01 2016M12			
Included observations: 72			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXPECTED	0.000268	1.794778	1.716180
UNEXPECTED	0.002296	1.597090	1.526939
EU10Y	0.006133	1.371183	1.262762
C	2.10E-05	1.102842	NA

Table 65: Histogram and Jarque-Bera test for residuals in model 7



14.3 Stability, Coefficient and Residuals statistics for estimated models for post-financial crisis.

The sample estimated during the post-financial period contained 48 observations.

Model 8: $\Delta 3\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Table 66: The Ramsey RESET test for model 8

Ramsey RESET Test			
Equation: UNTITLED			
Specification: NIBOR3M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.465067	44	0.6442
F-statistic	0.216287	(1, 44)	0.6442
Likelihood ratio	0.235371	1	0.6276

Table 67: Breusch-Godfrey autocorrelation test for model 8

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.310500	Prob. F(2,43)	0.7347
Obs*R-squared	0.683341	Prob. Chi-Square(2)	0.7106

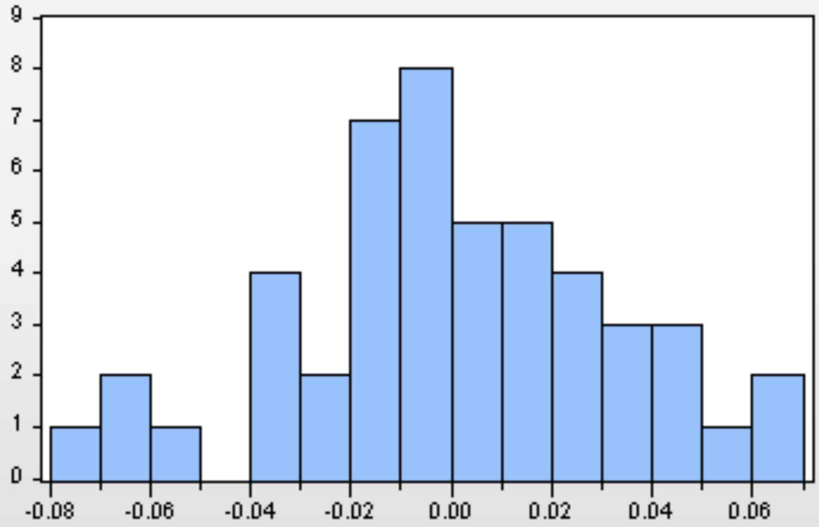
Table 68: The White test for model 8

Heteroskedasticity Test: White			
F-statistic	1.404099	Prob. F(5,42)	0.2425
Obs*R-squared	6.874344	Prob. Chi-Square(5)	0.2302

Table 69: Variance inflation factors for model 8

Variance Inflation Factors			
Date: 10/24/17 Time: 13:36			
Sample: 2009M10 2016M12			
Included observations: 48			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXP1M	0.002384	1.073765	1.034012
UNEX1M	0.004140	1.034496	1.034012
C	2.30E-05	1.038645	NA

Table 70: Histogram and Jarque-Bera test for residuals in model 8



Series: Residuals	
Sample 2009M10 2016M12	
Observations 48	
Mean	-1.41e-18
Median	-0.002318
Maximum	0.063635
Minimum	-0.074530
Std. Dev.	0.031917
Skewness	-0.162152
Kurtosis	2.799512
Jarque-Bera	0.290737
Probability	0.864704

Model 9: $\Delta 6\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(72 observations)

Table 71: The Ramsey RESET test for model 9

Ramsey RESET Test			
Equation: UNTITLED			
Specification: NIBOR6M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.306444	44	0.7607
F-statistic	0.093908	(1, 44)	0.7607
Likelihood ratio	0.102336	1	0.7490

Table 72: Breusch-Godfrey autocorrelation test for model 9

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.495227	Prob. F(2,43)	0.6129
Obs*R-squared	1.080731	Prob. Chi-Square(2)	0.5825

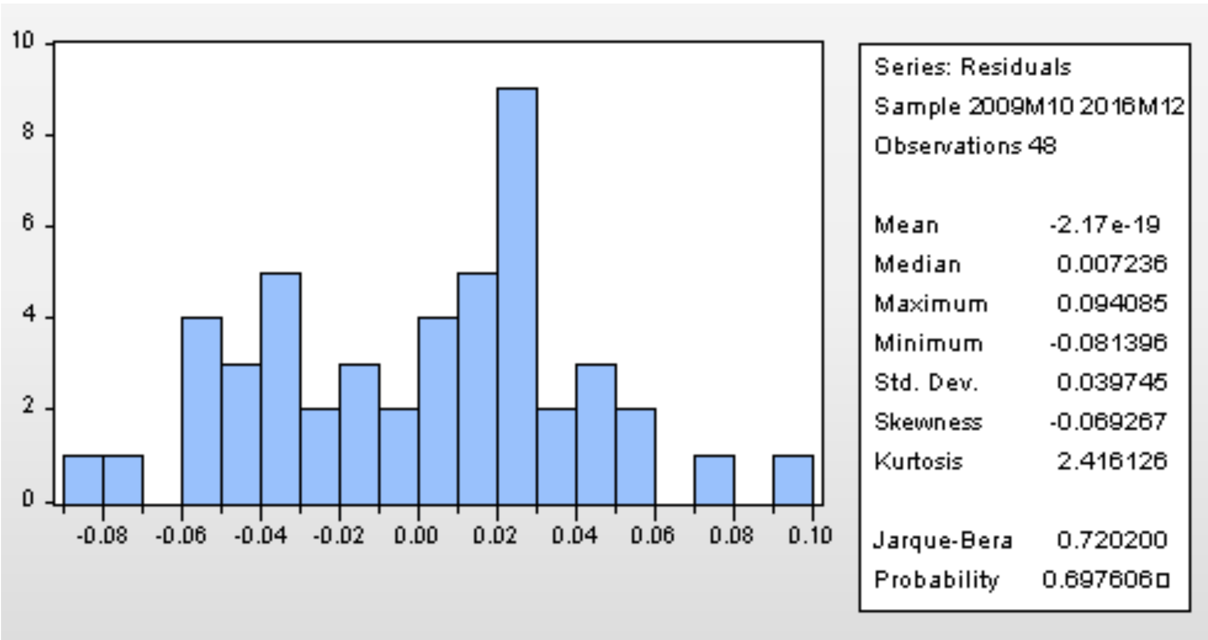
Table 73: The White test for model 9

Heteroskedasticity Test: White			
F-statistic	0.748029	Prob. F(5,42)	0.5921
Obs*R-squared	3.924932	Prob. Chi-Square(5)	0.5603

Table 74: Variance inflation factors for model 10

Variance Inflation Factors			
Date: 10/24/17 Time: 13:41			
Sample: 2009M10 2016M12			
Included observations: 48			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXP1M	0.003697	1.073765	1.034012
UNEX1M	0.006420	1.034496	1.034012
C	3.57E-05	1.038645	NA

Table 75: Histogram and Jarque-Bera test for residuals in model 9



Model 10: $\Delta 3\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(70 observations)

Table 76: Ramsey RESET test for model 10

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BILL_3M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.368493	44	0.7143
F-statistic	0.135787	(1, 44)	0.7143
Likelihood ratio	0.147903	1	0.7005

Table 77: Breusch-Godfrey autocorrelation test for model 10

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.464769	Prob. F(2,43)	0.6314
Obs*R-squared	1.015669	Prob. Chi-Square(2)	0.6018

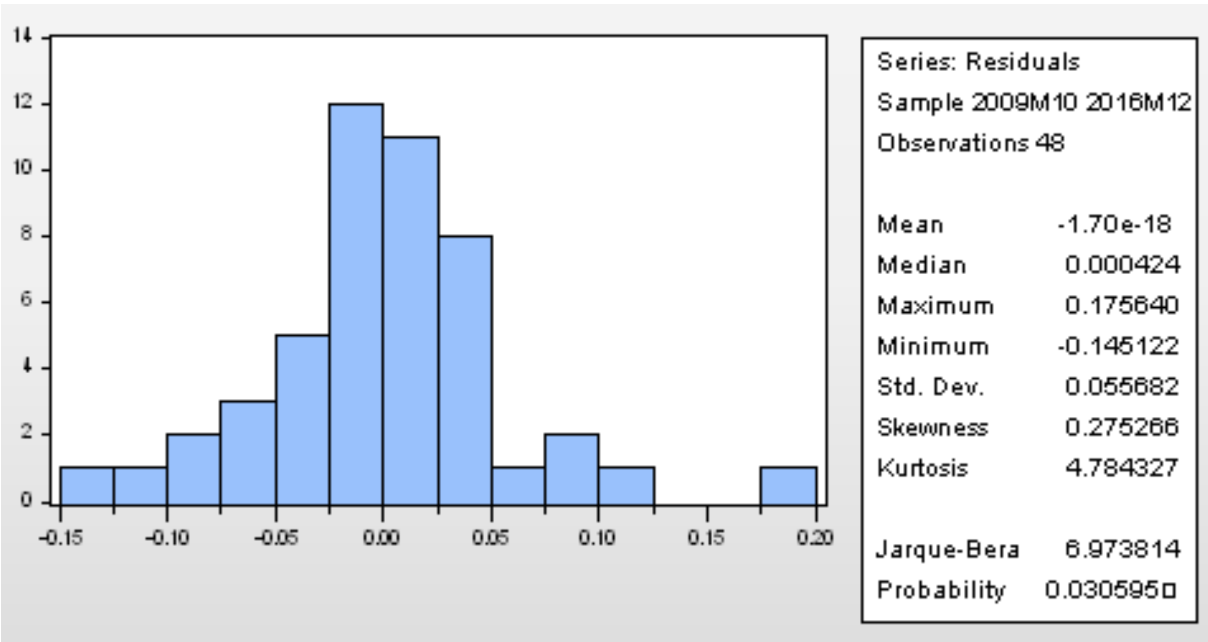
Table 78: The White test for model 10

Heteroskedasticity Test: White			
F-statistic	0.168202	Prob. F(5,42)	0.9729
Obs*R-squared	0.942288	Prob. Chi-Square(5)	0.9671

Table 79: Variance inflation factors for model 10

Variance Inflation Factors			
Date: 10/24/17 Time: 13:45			
Sample: 2009M10 2016M12			
Included observations: 48			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXP1M	0.007257	1.073765	1.034012
UNEX1M	0.012601	1.034496	1.034012
C	7.01E-05	1.038645	NA

Table 80: Histogram and Jarque-Bera test for residuals in model 10



Model 11: $\Delta 6\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(70 observations)

Table 81: Ramsey RESET test for model 11

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BILL_6M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.427501	44	0.6711
F-statistic	0.182757	(1, 44)	0.6711
Likelihood ratio	0.198958	1	0.6556

Table 82: Breusch-Godfrey autocorrelation test for model 11

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.725183	Prob. F(2,43)	0.4901
Obs*R-squared	1.566186	Prob. Chi-Square(2)	0.4570

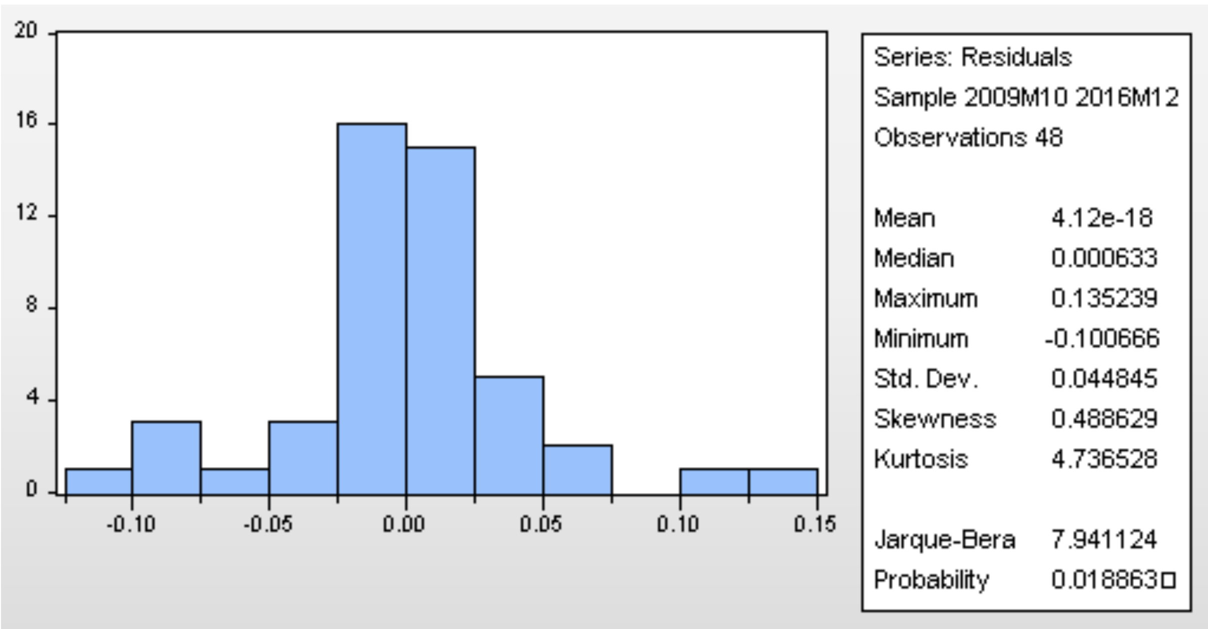
Table 83: The White test for model 11

Heteroskedasticity Test: White			
F-statistic	0.401407	Prob. F(5,42)	0.8451
Obs*R-squared	2.189143	Prob. Chi-Square(5)	0.8224

Table 84: Variance inflation factors for model 11

Variance Inflation Factors			
Date: 10/24/17 Time: 13:48			
Sample: 2009M10 2016M12			
Included observations: 48			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXP1M	0.004707	1.073765	1.034012
UNEX1M	0.008173	1.034496	1.034012
C	4.54E-05	1.038645	NA

Table 85: Histogram and Jarque-Bera test for residuals in model 11



Model 12: $\Delta 12\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

(70 observations)

Table 86: The Ramsey RESET test for model 12

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BILL_12M EXP1M UNEX1M C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.616409	44	0.5408
F-statistic	0.379960	(1, 44)	0.5408
Likelihood ratio	0.412722	1	0.5206

Table 87: Breusch-Godfrey autocorrelation test for model 12

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.794175	Prob. F(2,43)	0.1785
Obs*R-squared	3.697079	Prob. Chi-Square(2)	0.1575

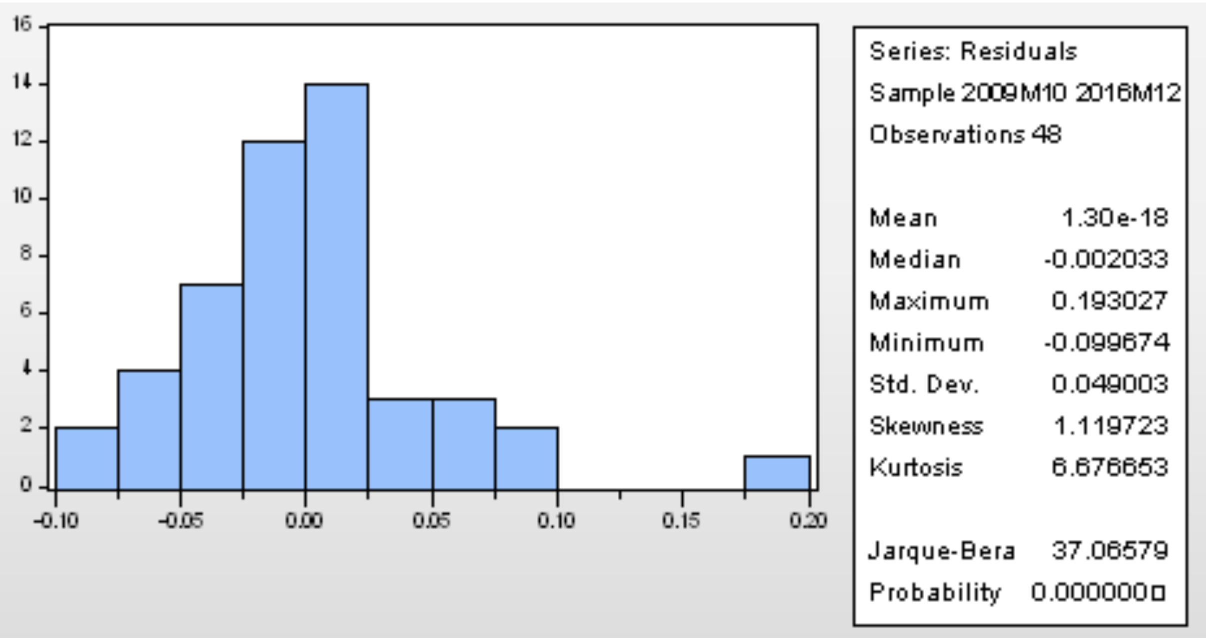
Table 88: The White test for model 12

Heteroskedasticity Test: White			
F-statistic	0.157761	Prob. F(5,42)	0.9765
Obs*R-squared	0.884873	Prob. Chi-Square(5)	0.9713

Table 89: Variance inflation factors for model 12

Variance Inflation Factors			
Date: 10/24/17 Time: 13:51			
Sample: 2009M10 2016M12			
Included observations: 48			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXP1M	0.005620	1.073765	1.034012
UNEX1M	0.009759	1.034496	1.034012
C	5.43E-05	1.038645	NA

Table 90: Histogram and Jarque-Bera test for residuals in model 12



Model 13: $\Delta 5\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 5\ year\ EGB_t + \varepsilon_t$, (72 observations)

Table 91: The Ramsey RESET test for model 13

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BOND5Y EXP1M UNEX1M EU5Y C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.406638	43	0.6863
F-statistic	0.165354	(1, 43)	0.6863
Likelihood ratio	0.184227	1	0.6678

Table 92: Breusch-Godfrey autocorrelation test for model 13

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.705783	Prob. F(2,42)	0.4995
Obs*R-squared	1.560762	Prob. Chi-Square(2)	0.4582

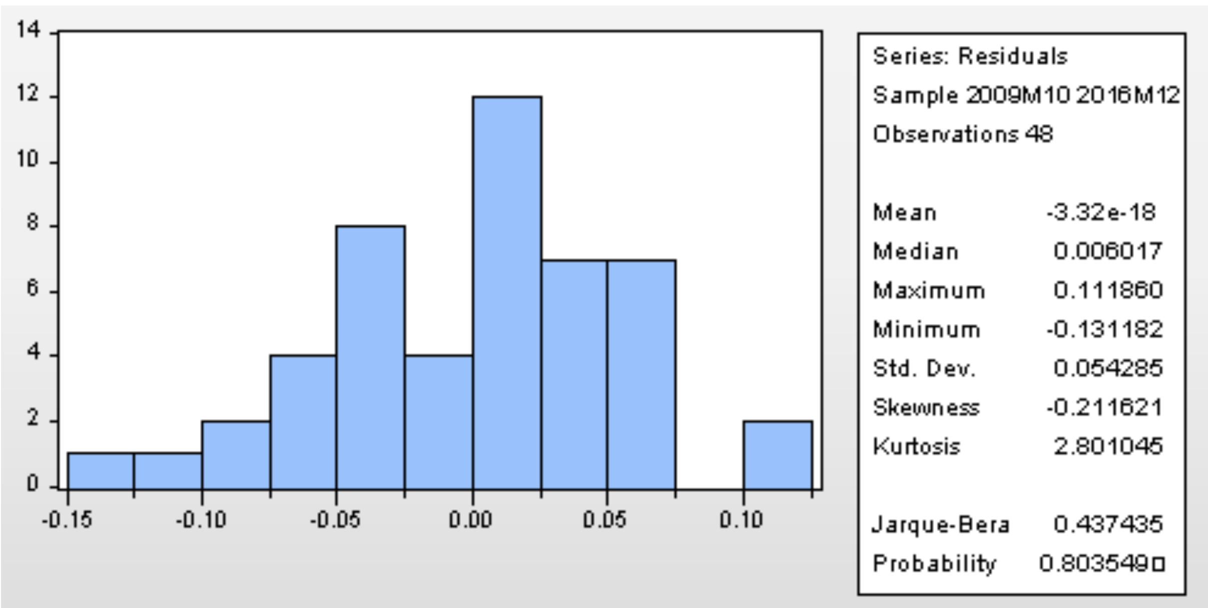
Table 93: The White test for model 13

Heteroskedasticity Test: White			
F-statistic	0.766932	Prob. F(9,38)	0.6470
Obs*R-squared	7.378551	Prob. Chi-Square(9)	0.5978

Table 94: Variance inflation factors for model 13

Variance Inflation Factors			
Date: 10/24/17 Time: 13:58			
Sample: 2009M10 2016M12			
Included observations: 48			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXP1M	0.007062	1.074990	1.035192
UNEX1M	0.012384	1.045988	1.045499
EU5Y	0.015820	1.028962	1.014002
C	6.92E-05	1.055902	NA

Table 95: Histogram and Jarque-Bera test for residuals in model 13



Model 14: $\Delta 10\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 10\ year\ EGB_t + \varepsilon_t$, (72 observations)

Table 96: The Ramsey RESET test for model 14

Ramsey RESET Test			
Equation: UNTITLED			
Specification: BOND10Y EXP1M UNEX1M EU10Y C			
Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	1.280070	43	0.2074
F-statistic	1.638580	(1, 43)	0.2074
Likelihood ratio	1.795123	1	0.1803

Table 97: Breusch-Godfrey autocorrelation test for model 14

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.233570	Prob. F(2,42)	0.7927
Obs*R-squared	0.528002	Prob. Chi-Square(2)	0.7680

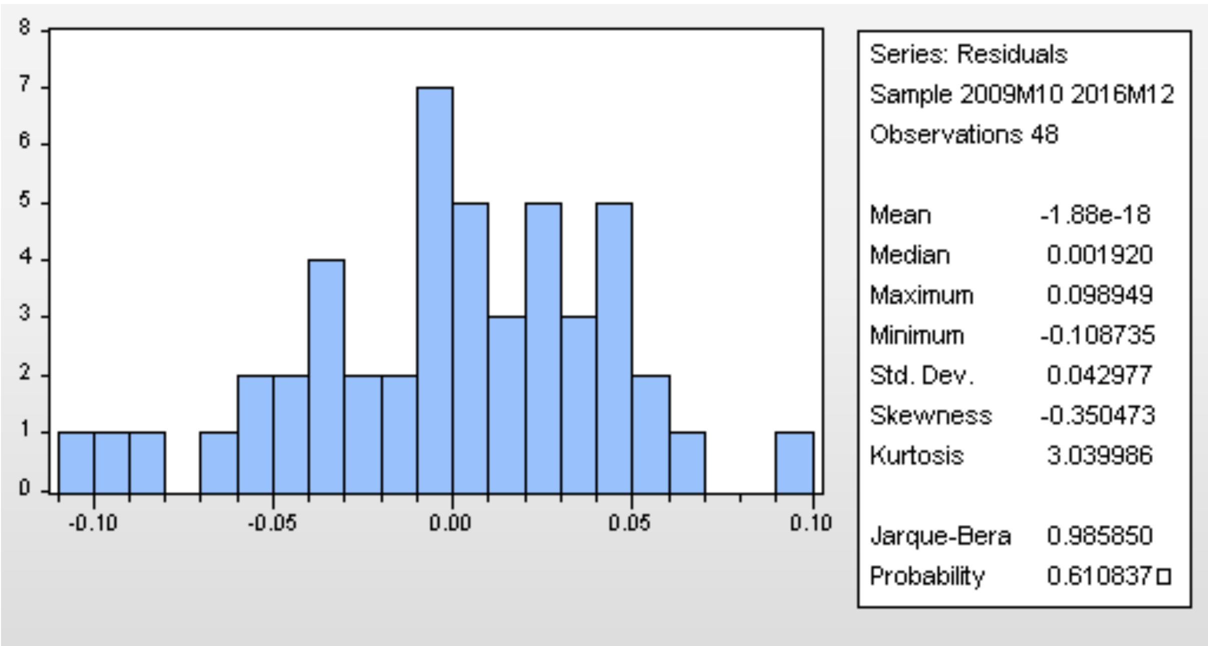
Table 98: The White test for model 14

Heteroskedasticity Test: White			
F-statistic	2.347335	Prob. F(9,38)	0.0323
Obs*R-squared	17.15063	Prob. Chi-Square(9)	0.0464

Table 99: Variance inflation factors for model 14

Variance Inflation Factors			
Date: 10/24/17 Time: 14:03			
Sample: 2009M10 2016M12			
Included observations: 48			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
EXP1M	0.005438	1.193515	1.014317
UNEX1M	0.008725	1.013512	1.012868
EU10Y	0.006246	1.056409	1.024092
C	4.12E-05	1.194809	NA

Table 100: Histogram and Jarque-Bera test for residuals in model 14



15. Appendix D

15.1 Results for entire sample

Figure 17: Model 1: $\Delta 3\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Whole sample: 72 observations

Robust standard errors are obtained with Newey-West estimator

Dependent Variable: NIBOR3M				
Method: Least Squares				
Date: 10/23/17 Time: 19:08				
Sample: 2007M01 2016M12				
Included observations: 72				
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXPECTED	0.030377	0.036878	0.823729	0.4129
UNEXPECTED	1.040534	0.073199	14.21511	0.0000
C	0.001792	0.005035	0.356002	0.7229
R-squared	0.814189	Mean dependent var		-0.000417
Adjusted R-squared	0.808803	S.D. dependent var		0.122526
S.E. of regression	0.053576	Akaike info criterion		-2.974674
Sum squared resid	0.198053	Schwarz criterion		-2.879813
Log likelihood	110.0883	Hannan-Quinn criter.		-2.936910
F-statistic	151.1727	Durbin-Watson stat		2.316214
Prob(F-statistic)	0.000000	Wald F-statistic		175.4969
Prob(Wald F-statistic)	0.000000			

Figure 18: Model 2: $\Delta 6\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Whole sample: 72 observations

Dependent Variable: NIBOR6M				
Method: Least Squares				
Date: 10/23/17 Time: 19:34				
Sample: 2007M01 2016M12				
Included observations: 72				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXPECTED	-0.008158	0.033087	-0.246575	0.8060
UNEXPECTED	0.935491	0.073624	12.70628	0.0000
C	-0.000721	0.007490	-0.096239	0.9236
R-squared	0.711874	Mean dependent var		-0.001389
Adjusted R-squared	0.703523	S.D. dependent var		0.115177
S.E. of regression	0.062713	Akaike info criterion		-2.659711
Sum squared resid	0.271375	Schwarz criterion		-2.564850
Log likelihood	98.74959	Hannan-Quinn criter.		-2.621946
F-statistic	85.23930	Durbin-Watson stat		2.526752
Prob(F-statistic)	0.000000			

Figure 19: Model 3: $\Delta 3\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Whole sample: 70 observations

Dependent Variable: BILL_3M				
Method: Least Squares				
Date: 10/23/17 Time: 19:37				
Sample: 2007M01 2016M12				
Included observations: 70				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	0.024245	0.041902	0.578625	0.5648
UNEX1M	0.455745	0.092642	4.919429	0.0000
C	-0.006899	0.008736	-0.789690	0.4325
R-squared	0.312112	Mean dependent var		-0.010335
Adjusted R-squared	0.291578	S.D. dependent var		0.086226
S.E. of regression	0.072575	Akaike info criterion		-2.366486
Sum squared resid	0.352896	Schwarz criterion		-2.270122
Log likelihood	85.82702	Hannan-Quinn criter.		-2.328209
F-statistic	15.19980	Durbin-Watson stat		2.119054
Prob(F-statistic)	0.000004			

Figure 20: Model 4: $\Delta 6\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Whole sample: 70 observations

Dependent Variable: BILL_6M				
Method: Least Squares				
Date: 10/23/17 Time: 19:39				
Sample: 2007M01 2016M12				
Included observations: 70				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	0.075542	0.027284	2.768756	0.0073
UNEX1M	0.334378	0.060323	5.543146	0.0000
C	-0.002582	0.005688	-0.453894	0.6514
R-squared	0.457191	Mean dependent var		-0.006604
Adjusted R-squared	0.440987	S.D. dependent var		0.063205
S.E. of regression	0.047256	Akaike info criterion		-3.224550
Sum squared resid	0.149622	Schwarz criterion		-3.128186
Log likelihood	115.8593	Hannan-Quinn criter.		-3.186273
F-statistic	28.21596	Durbin-Watson stat		2.331665
Prob(F-statistic)	0.000000			

Figure 21: Model 5: $\Delta 12\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Whole sample: 70 observations

Robust standard errors are obtained with Newey-West estimator

Dependent Variable: BILL_12M				
Method: Least Squares				
Date: 10/23/17 Time: 19:41				
Sample: 2007M01 2016M12				
Included observations: 70				
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	0.124731	0.029353	4.249343	0.0001
UNEX1M	0.423185	0.070070	6.039482	0.0000
C	-0.003269	0.004554	-0.717830	0.4754
R-squared	0.557045	Mean dependent var		-0.009116
Adjusted R-squared	0.543823	S.D. dependent var		0.078606
S.E. of regression	0.053091	Akaike info criterion		-2.991697
Sum squared resid	0.188852	Schwarz criterion		-2.895333
Log likelihood	107.7094	Hannan-Quinn criter.		-2.953420

Figure 22: Model 6: $\Delta 5\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 5\ year\ EGB_t + \varepsilon_t$

The whole sample: 72 observations

Dependent Variable: BOND5Y				
Method: Least Squares				
Date: 10/23/17 Time: 19:43				
Sample: 2007M01 2016M12				
Included observations: 72				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EU5Y	0.412426	0.096071	4.292905	0.0001
UNEX1M	0.186759	0.062414	2.992263	0.0039
EXP1M	0.052582	0.028160	1.867241	0.0662
C	-0.004362	0.006315	-0.690692	0.4921
R-squared	0.395796	Mean dependent var		-0.009717
Adjusted R-squared	0.369140	S.D. dependent var		0.066304
S.E. of regression	0.052663	Akaike info criterion		-2.995851
Sum squared resid	0.188591	Schwarz criterion		-2.869369
Log likelihood	111.8506	Hannan-Quinn criter.		-2.945498
F-statistic	14.84824	Durbin-Watson stat		2.128596

Figure 23: Model 7: $\Delta 10\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 10\ year\ EGB_t + \varepsilon_t$

The whole sample: 72 observations

Dependent Variable: BOND10Y				
Method: Least Squares				
Date: 10/23/17 Time: 19:45				
Sample: 2007M01 2016M12				
Included observations: 72				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EU10Y	0.695928	0.083511	8.333333	0.0000
EXP1M	0.044471	0.021599	2.058908	0.0433
UNEX1M	0.099787	0.048176	2.071293	0.0421
C	-0.000371	0.004841	-0.076691	0.9391
R-squared	0.598719	Mean dependent var		-0.006032
Adjusted R-squared	0.581016	S.D. dependent var		0.062477
S.E. of regression	0.040441	Akaike info criterion		-3.524011
Sum squared resid	0.111210	Schwarz criterion		-3.397529
Log likelihood	130.8644	Hannan-Quinn criter.		-3.473658
F-statistic	33.81916	Durbin-Watson stat		2.046772

15.2 Results – Post-financial Period

Figure 24: Model 8: $\Delta 3\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Post financial crisis: 48 observations

Dependent Variable: NIBOR3M				
Method: Least Squares				
Date: 10/24/17 Time: 14:07				
Sample: 2009M10 2016M12				
Included observations: 48				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	-0.037471	0.048830	-0.767387	0.4469
UNEX1M	0.915234	0.064343	14.22422	0.0000
C	-0.005081	0.004798	-1.058877	0.2953
R-squared	0.820520	Mean dependent var		-0.005833
Adjusted R-squared	0.812544	S.D. dependent var		0.075338
S.E. of regression	0.032619	Akaike info criterion		-3.947399
Sum squared resid	0.047879	Schwarz criterion		-3.830449
Log likelihood	97.73757	Hannan-Quinn criter.		-3.903203
F-statistic	102.8625	Durbin-Watson stat		2.089628
Prob(F-statistic)	0.000000			

Figure 25: Model 9: $\Delta 6\ Month\ Nibor_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Post financial crisis: 48 observations

Dependent Variable: NIBOR6M				
Method: Least Squares				
Date: 10/24/17 Time: 14:08				
Sample: 2009M10 2016M12				
Included observations: 48				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	-0.046557	0.060806	-0.765657	0.4479
UNEX1M	0.809495	0.080125	10.10293	0.0000
C	-0.007509	0.005975	-1.256703	0.2153
R-squared	0.696450	Mean dependent var		-0.007917
Adjusted R-squared	0.682959	S.D. dependent var		0.072139
S.E. of regression	0.040619	Akaike info criterion		-3.508697
Sum squared resid	0.074246	Schwarz criterion		-3.391747
Log likelihood	87.20873	Hannan-Quinn criter.		-3.464501
F-statistic	51.62281	Durbin-Watson stat		2.244493
Prob(F-statistic)	0.000000			

Figure 26: Model 10: $\Delta 3\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Post financial crisis: 48 observations

Dependent Variable: BILL_3M				
Method: Least Squares				
Date: 10/24/17 Time: 14:10				
Sample: 2009M10 2016M12				
Included observations: 48				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	-0.032383	0.085187	-0.380141	0.7056
UNEX1M	0.595171	0.112252	5.302088	0.0000
C	-0.002446	0.008371	-0.292156	0.7715
R-squared	0.387436	Mean dependent var		-0.002781
Adjusted R-squared	0.360211	S.D. dependent var		0.071144
S.E. of regression	0.056906	Akaike info criterion		-2.834371
Sum squared resid	0.145723	Schwarz criterion		-2.717421
Log likelihood	71.02491	Hannan-Quinn criter.		-2.790175
F-statistic	14.23088	Durbin-Watson stat		1.940056
Prob(F-statistic)	0.000016			

Figure 27: Model 11: $\Delta 6\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Post financial crisis: 48 observations

Dependent Variable: BILL_6M				
Method: Least Squares				
Date: 10/24/17 Time: 14:10				
Sample: 2009M10 2016M12				
Included observations: 48				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	-0.106520	0.068607	-1.552614	0.1275
UNEX1M	0.440177	0.090404	4.868987	0.0000
C	-0.007815	0.006742	-1.159179	0.2525
R-squared	0.349434	Mean dependent var		-0.006475
Adjusted R-squared	0.320520	S.D. dependent var		0.055599
S.E. of regression	0.045830	Akaike info criterion		-3.267284
Sum squared resid	0.094518	Schwarz criterion		-3.150334
Log likelihood	81.41482	Hannan-Quinn criter.		-3.223089
F-statistic	12.08529	Durbin-Watson stat		2.039290
Prob(F-statistic)	0.000063			

Figure 28: Model 12**:** $\Delta 12\ Month\ Treasury_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \varepsilon_t$

Post financial crisis: 48 observations

Dependent Variable: BILL_12M				
Method: Least Squares				
Date: 10/24/17 Time: 14:12				
Sample: 2009M10 2016M12				
Included observations: 48				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	0.001478	0.074969	0.019713	0.9844
UNEX1M	0.519223	0.098787	5.255988	0.0000
C	-0.001160	0.007367	-0.157444	0.8756
R-squared	0.388623	Mean dependent var		-0.002024
Adjusted R-squared	0.361450	S.D. dependent var		0.062671
S.E. of regression	0.050080	Akaike info criterion		-3.089935
Sum squared resid	0.112860	Schwarz criterion		-2.972985
Log likelihood	77.15844	Hannan-Quinn criter.		-3.045739
F-statistic	14.30214	Durbin-Watson stat		2.367155
Prob(F-statistic)	0.000016			

Figure 29: Model 13: $\Delta 5\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 5\ year\ EGB_t + \varepsilon_t$

Post financial crisis: 48 observations

Dependent Variable: BOND5Y				
Method: Least Squares				
Date: 10/24/17 Time: 14:14				
Sample: 2007M01 2016M12				
Included observations: 72				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	0.052582	0.028160	1.867241	0.0662
UNEX1M	0.186759	0.062414	2.992263	0.0039
EU5Y	0.412426	0.096071	4.292905	0.0001
C	-0.004362	0.006315	-0.690692	0.4921
R-squared	0.395796	Mean dependent var		-0.009717
Adjusted R-squared	0.369140	S.D. dependent var		0.066304
S.E. of regression	0.052663	Akaike info criterion		-2.995851
Sum squared resid	0.188591	Schwarz criterion		-2.869369
Log likelihood	111.8506	Hannan-Quinn criter.		-2.945498
F-statistic	14.84824	Durbin-Watson stat		2.128596

Figure 30: Model 14**:** $\Delta 10\ Year\ Bond_t = \alpha + \beta_1 \Delta Expected_t + \beta_2 \Delta Unexpected_t + \beta_3 \Delta 10\ year\ EGB_t + \varepsilon_t$

Post financial crisis: 48 observations

Robust standard errors are obtained with Newey-West estimator

Dependent Variable: BOND10Y				
Method: Least Squares				
Date: 10/24/17 Time: 14:15				
Sample: 2009M10 2016M12				
Included observations: 48				
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed				
bandwidth = 4.0000)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP1M	0.119770	0.073746	1.624098	0.1115
UNEX1M	0.047232	0.093406	0.505666	0.6156
EU10Y	0.707290	0.079033	8.949352	0.0000
C	0.002303	0.006416	0.358949	0.7213
R-squared	0.531465	Mean dependent var		-0.004850
Adjusted R-squared	0.499520	S.D. dependent var		0.062786
S.E. of regression	0.044417	Akaike info criterion		-3.310711
Sum squared resid	0.086808	Schwarz criterion		-3.154778

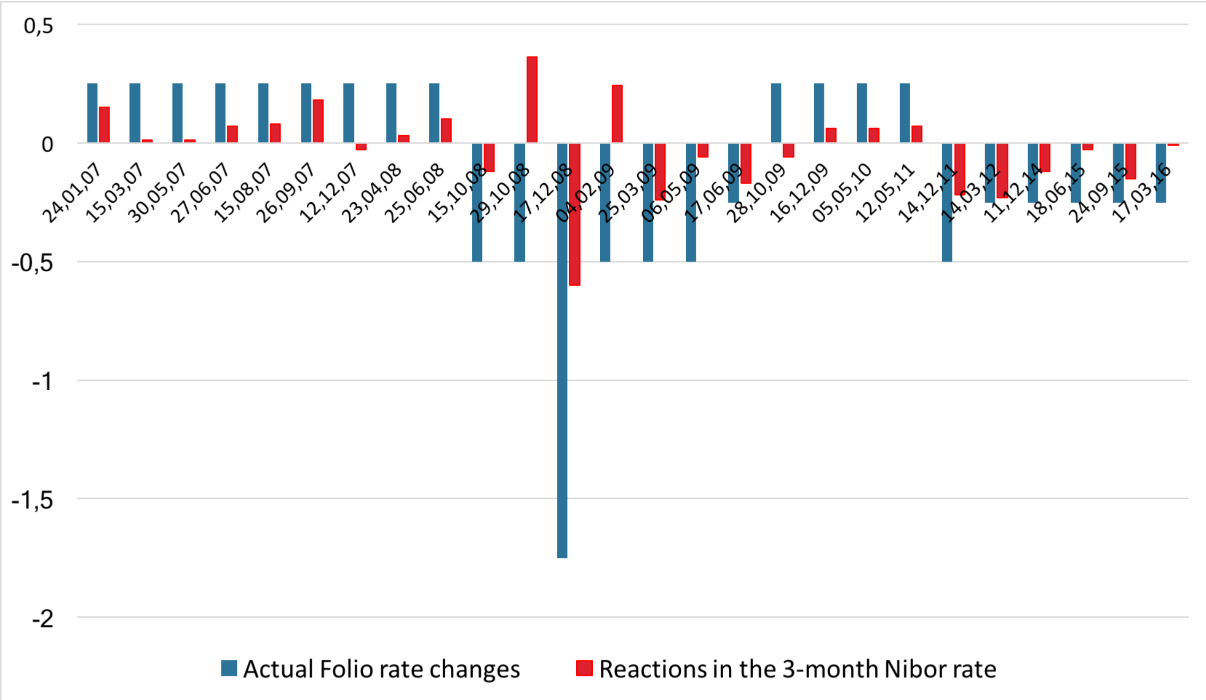
16. Appendix E:

16.1 Different Figures

Table 101: Observed, and the expected and unexpected portion of the Folio rate change. Time period: 08.02.07 – 13.03.17. In percent.

Date	Folio Change	Unexpected Change	Expected Change
24.1.2007	0,25	0,1200	0,1300
15.3.2007	0,25	-0,0140	0,2640
30.5.2007	0,25	0,0080	0,2420
27.6.2007	0,25	-0,0080	0,2580
15.8.2007	0,25	0,0680	0,1820
26.9.2007	0,25	0,1860	0,0640
12.12.2007	0,25	0,0240	0,2260
23.4.2008	0,25	-0,0080	0,2580
25.6.2008	0,25	-0,0160	0,2660
15.10.2008	-0,50	0,6583	-1,1583
17.12.2008	-1,75	-0,5049	-1,2451
4.2.2009	-0,50	0,2712	-0,7712
25.3.2009	-0,50	-0,0488	-0,4512
6.5.2009	-0,50	-0,0888	-0,4112
17.6.2009	-0,25	-0,1224	-0,1276
28.10.2009	0,25	0,0304	0,2196
16.12.2009	0,25	0,0924	0,1576
5.5.2010	0,25	0,1324	0,1176
12.5.2011	0,25	0,0684	0,1816
14.12.2011	-0,50	-0,2348	-0,2652
14.3.2012	-0,25	-0,1784	-0,0716
11.12.2014	-0,25	-0,1184	0,1184
18.6.2015	-0,25	-0,0284	-0,2216
24.9.2015	-0,25	-0,1564	-0,0936
17.3.2016	-0,25	-0,0204	-0,2296

Figure 31: Changes in the 3-month Nibor rate due to a Folio rate change



Actual Folio rate changes and 3-month Nibor reaction. In percent. Data source: Norges Bank og Oslo stock exchange.

Figure 32: 3-Month Nibor model, Residual plot.

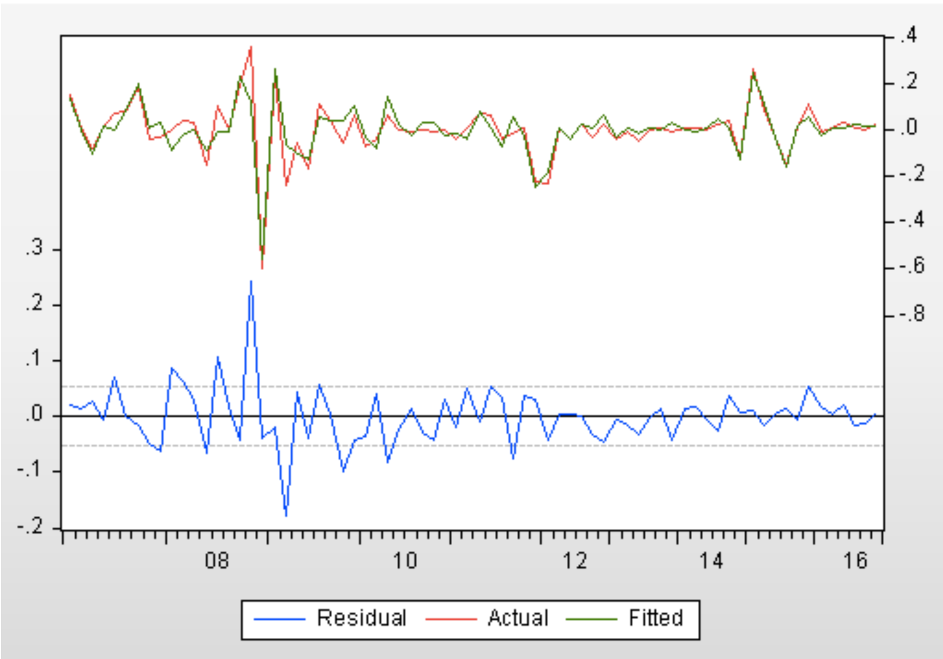


Figure 33: 10-year Bond model, post-financial crisis, Residual plot.