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The More the Merrier?

A Factor-augmented VAR Analysis of the Norwegian
Monetary Policy Transmission Mechanism

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Abstract

How does an economy respond when policymakers change interest rates? In this thesis we seek to answer this question by examining the Norwegian monetary policy transmission mechanism. Further, we discuss the evolution in macroeconomic thought on the monetary policy transmission mechanism and present related empirical evidence. In particular, we use a Factor-augmented Vector Autoregression (FAVAR) approach to examine the policy instrument effect over the last twenty-five years, where we assess the response of a contractionary monetary shock on a broad dataset of 102 variables across the Norwegian economy.

Present-day policymakers monitor a large set of variables in their decision-making. In order to reduce the omitted-information problem of small-scale vector autoregression (VAR) models, we combine the VAR methodology with dynamic factor analysis to assess the effect of a monetary policy shock on the Norwegian economy. Specifically, the FAVAR model allows us to better capture the dynamics of the economy by being designed to handle a large information set, thereby minimizing the probability of biased results. Utilizing a rich dataset of 103 macroeconomic variables, spanning from 1990:M1 to 2016:M9, we add to the literature by examining and evaluating the transmission mechanism of monetary policy in Norway.

The results indeed show that the policy effect is strong and significant across a broad set of variables in the economy. Furthermore, the results are broadly in line with economic intuition, indicating a dampening effect on real activity following a contractionary monetary policy. These findings are consistent with the effects found in earlier literature for the U.S. economy (Bernanke, Boivin, et al., 2005; Stock and Watson, 2005), and provides valuable insight on the transmission mechanism of monetary policy in Norway.

Keywords: Norway, Monetary Policy, Transmission Mechanism, FAVAR.

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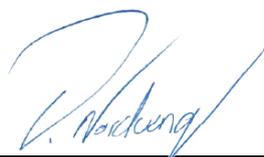
This master thesis is written as part of the Master of Science program at the Norwegian School of Economics, and constitutes 30 ECTS of the study.

The process of writing the thesis has certainly proved challenging and demanding, but we feel fortunate to be able to study a topic of our own choice. Examining the topic of the monetary transmission mechanism is important from a public perspective, since Norges Bank's monetary policy setting affects all participants in the Norwegian economy. Hence, the in-depth research of both a personally exciting topic and a widespread important mechanism has proved rewarding. Further, the process of analyzing the transmission mechanism has yielded us a greater understanding of the complex decision that the Executive Board of Norges Bank has to make when deciding the key policy rate.

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Contents

Introduction	2
1.1 Motivation and Purpose	2
1.2 Research Question	4
Monetary Policy	5
2.1 Norwegian Monetary Policy Regimes	5
2.1.1 The Pre-inflation Targeting Period	5
2.1.2 New Guidelines for Monetary Policy	6
2.2 The Inflation-targeting Framework	7
2.3 The Monetary Policy Transmission Mechanism	11
2.3.1 Interest Rate Channel	13
2.3.2 Asset Price Channel	14
2.3.3 Credit Channel	15
2.3.4 The Exchange Rate Channel	17
2.3.5 Expectations and Confidence Channel	17
Literature Review	19
3.1 The Vector Autoregression	19
3.2 The Factor-augmented VAR	23
3.3 Results in the Empirical Literature	24
3.3.1 Transmission of Shock in a Norwegian Context	25
3.3.2 Changes in the Monetary Transmission Mechanism	26
Empirical Methodology	28
4.1 Vector Autoregression	28
4.2 Factor Analysis	29
4.3 The Factor-Augmented VAR	32
Empirical Implementation	35
5.1 Data	35
5.2 Model Specification	37
5.2.1 Identification of Factors	38
5.2.2 Identification of the Factor-augmented VAR	39
Results	41
6.1 Impulse Responses	41
6.1.1 Changes in the Monetary Transmission Mechanism	43

6.2	Robustness	46
6.2.1	Number of Factors	46
6.2.2	Oil Price and Exchange Rate as Observed Variables	47
	Concluding Remarks and Further Research	51
7.1	Discussion and Conclusion	51
7.2	Further Research	53
	References	55
	Appendices	64
A	Data Description and Transformation	65
B	Recovered Structural Shocks	71
C	Model Selection	72
D	Descriptive Data for Factor Analysis	75

Introduction

How does an economy respond when policymakers change interest rates? Moreover, can those responses change in response to different policy regimes? These questions are of crucial importance to monetary policymakers as they go to the heart of how interest rates is used to underpin growth and ensure price stability.

The transmission mechanism of monetary policy is one of the most studied fields of economics for two particular reasons (Boivin, Kiley, et al., 2010). First, insight about how monetary policy affects the economy is fundamental to assess the position of monetary policy at a particular point in time. Although a central bank's policy instrument, for example, the key policy rate in Norway, is low, the scope of monetary policy may well be limited due to its effect on other asset prices and quantities (e.g. housing and credit market). Second, in order to optimize the monetary policy decision, policymakers must have an accurate assessment of how both the *timing* and the *effect* of their policy changes influence the economy. To make this judgment, they need to understand the mechanisms in which monetary policy influences real economic activity, inflation and expectations.

Over the last three decades there have been powerful changes in the way the economy operates, where especially the increased globalization have contributed in shaping nowadays societies. In addition, the management and objective of monetary policy have changed, with strengthened attention towards stable price development. Moreover, cutting edge research in monetary economics has added new reflections on how monetary policy affects the economy, leading to further progression in our perception of the monetary transmission mechanism. In sum, these developments indicate a firm possibility that the monetary transmission mechanism has changed over the last three decades.

1.1 Motivation and Purpose

This thesis aims to examine and quantify the effect of a monetary policy shock on real activity, asset prices, and inflation in the Norwegian economy. Further, to reflect Norges Bank's choice of monetary policy regime, this thesis separates the analysis between two sample periods, namely, the pre- and post-inflation targeting eras (pre- and post-1999:M6). The choice of subject is motivated by the ongoing debate about the role of financial variables in the business cycle and monetary policy transmission mechanism. Both in academia and in the central banking community there is little disagreement that the source of the

recent crisis can be traced back to the financial markets.¹ There is, however, no unity on which factors that contributed to the imbalances prior to the crisis. Svensson (2010) point to the liberalization of credit markets, and as a result, a slacker regulatory regime, while others argue that the expansionary monetary policy has augmented the downturn (John B Taylor, 2007).

Moreover, as emphasized by both The International Monetary Fund (2017) and the latest Monetary Policy Report (MPR) published by Norges Bank, the recent boom in housing prices and household debt in Norway poses an important stability risk for the Norwegian economy (Norges Bank, 2017b). Following the rise in real house prices by 80 percent since 2000, Norges Bank has been forced to take housing price development and credit growth into consideration when deciding the key policy rate, as this channel could be an important transmitter of shocks. Hence, understanding the role of asset prices and credit in the transmission mechanism of monetary policy is essential for the implementation of an effective policy strategy.

Further, this thesis seeks to address the challenges confronted in standard empirical models used to examine the transmission mechanism, that are heavily criticized for being too small to integrate the broad and complex interlinkages of the economy. Our methodology is structured on vector autoregression (VAR), where we build on, for example, the paper by Christiano et al. (1998) by expanding their analysis to include the more contemporary factor-augmented VAR (FAVAR) approach following Bernanke, Boivin, et al. (2005). Using the FAVAR model, which encompasses a richer data set, we are able to better represent Norges Bank's considerations in their decision-making, and hence, reduce the risk of obtaining misleading results originating from a poorly specified model.

This thesis contributes to the literature from an empirical perspective by following the methodological framework as proposed by Bernanke, Boivin, et al. (2005) for the Norwegian economy. Moreover, to prevent biased results, Norges Bank's choice of monetary policy conduction is reflected by separating the analysis into two sub-samples, reflecting the informal regime shift to inflation targeting from 1999.² The empirical contribution is mainly related to the identification of the *complete* Norwegian monetary policy transmission mechanism.³ Hence, similar to Boivin, Kiley, et al. (2010), we therefore argue that our results will be superior to studies using less information. The existing literature on the

¹For a discussion, see for example Reinhart and Rogoff (2014), Bagliano and Morana (2012), and Cardarelli et al. (2011).

²This strategy follows Boivin, Kiley, et al. (2010), and allows us to examine and compare the monetary policy transmission mechanism in between the two eras.

³Where *complete* is defined with respect to the information set included and analyzed in our thesis, which is admittedly large.

monetary transmission mechanism in the Norwegian economy is rather limited, where previous research is centered on the role of housing prices and credit (Bjørnland and Jacobsen, 2010; Robstad, 2014), and the exchange rate (Bjørnland, 2009).

1.2 Research Question

Based on the previous section, this thesis aims to study the following:

I) What is the impact of a monetary policy shock on real activity, asset prices and inflation? Moreover, can we identify the channels in which the monetary policy operates?

II) Can we identify response changes between the pre- and post-inflation targeting regime in Norway?

The remainder of the paper continues as follows. In section 2, we present the theoretical framework for the monetary policy regime in Norway, and review the monetary policy transmission mechanism. We present existing literature in section 3, before specifying the econometric framework in section 4. Further, we describe our data and the empirical implementation in section 5. In section 6, the results are presented along with a robustness check. Finally, in section 7, we conclude and point towards further research on the monetary policy transmission mechanism in Norway.

Monetary Policy

Over the past decades, one of the most productive research areas within macroeconomics has been the monetary economics field, where the desire of researchers to master the relationships between monetary policy, inflation and the business cycle has led to numerous papers contributing to the insight of how monetary policy affects the economy (Galí, 2015).

The necessity for grasping the connection between monetary policy and the aggregate economy is self-evident. Consumers, workers, and investors care about changes in inflation, employment, and other economy-wide variables as those developments affect their opportunities to maintain or improve their standard of living. Moreover, changes in the monetary policy rate have a direct impact on the valuation of financial assets and their expected returns, as well as on the consumption and investment decisions of households and firms. Those decisions can in turn have consequences for output, employment, and inflation. Thus, it is not surprising that the policy rate decision made by the FED, the ECB, or Norges Bank is getting a lot of public attention.

In the following sections, we review the Norwegian monetary policy regime, the inflation-targeting framework as conducted by Norges Bank, and the transmission mechanism of monetary policy.

2.1 Norwegian Monetary Policy Regimes

The Central Bank of Norway, Norges Bank, has since 1985 had the responsibility of conducting monetary policy, credit policy, and currency policy in Norway.⁴ In March 2001, a monetary policy regulation promoted by the Norwegian Ministry of Finance was incorporated, introducing a monetary policy objective of low and stable inflation, with an explicit inflation target of 2.5 per cent.⁵ Further, the regulation says that Norges Bank should aim at stabilizing the Norwegian Krone (NOK) and its expected currency development. In addition, the monetary policy should be oriented towards supporting the fiscal policy by ensuring stable development in output and employment.

2.1.1 The Pre-inflation Targeting Period

In advance of the introduction of an explicit inflation target, monetary policy shifted between different regimes. During the 70s and early 80s, the policymakers' decisions amplified

⁴“Lov om Norges Bank og pengevesenet mv. (Sentralbankloven) § 1”

⁵“Forskrift om pengepolitikk § 1”

the large fluctuations in production and employment, causing high and unstable inflation (Gjedrem, 2005). Norges Bank experienced limited independence during this period, where their role was to serve as economic advisers for the political authorities in their conduct of monetary policy (Stoltz et al., 2015). The objective for monetary policy was oriented towards strengthening the competitiveness of the internationally exposed sector, achieved through a fixed exchange rate system with unpredictable devaluations. This rather naïve Keynesian monetary policy framework was built on the belief that the policymakers could influence growth and unemployment, at the cost of higher inflation (Thøgersen, 2011).

Throughout the second part of the 80s, a growing political recognition emerged in targeting the monetary policy towards low and stable inflation (Gjedrem, 2005). Based on Kydland and Prescott's work, the focus shifted towards how expectations affected agents in the economy, implying the need for a credible anchor in the conduct of monetary policy. Therefore, the low interest regime with the accompanying sky-high inflation ended in 1986, as Norges Bank was given the responsibility of the key policy rate decision. The Bank then continued on a fixed exchange policy, however, this time, without devaluing the currency throughout the rest of the 80s (Kleivset, 2011).

Further, in December 1992, Norges Bank, along with many European countries, had to revise their fixed exchange policy due to a protracted and comprehensive period of speculative currency attacks (Gjedrem, 2005). The new policy was somewhat softer, where the key policy rate was set with an objective of keeping the NOK stable against our key European trading partners, without defining any fixed rate. In addition, fiscal policy objectives were oriented towards stabilizing the mainland economy (Thøgersen, 2011). However, with increasing revenues from the petroleum sector, related to both investments and income, it proved difficult to dampen the mainland economy through the government budget. Moreover, with the semi-fixed exchange rate regime against the European basket currencies, the monetary policy had to adapt towards European interest rate levels, causing a further augmentation of the Norwegian business cycles throughout the early-90s.

2.1.2 New Guidelines for Monetary Policy

Following the troublesome semi-fixed exchange policy, along with experiences from the 70s to the 90s, The Norwegian Ministry of Finance *officially* agreed upon new guidelines for fiscal and monetary policy in 2001. However, the *informal* implementation of an inflation targeted monetary policy started already in June, 1999, with a goal of keeping inflation at 2 percent over time (Gjedrem, 2010).

The current mandate of Norges Bank, which is unchanged since the introduction in 2001,

states that the Bank should aim to stabilize the value of the Norwegian krone, and thereby contribute to stabilize expectations regarding the development in the exchange rate. In addition, monetary policy should support fiscal policy by contributing to stable developments in output and employment (Norges Bank, 2003). The mandate is followed through an operational target of an annual consumer price inflation of approximately 2.5 percent over time, 0.5 percent higher than our most important trading partners at the time of implementation (Roger, 2010). The rationale for setting the inflation target 50 basis points above our trading partners, was that Norway in the same period implemented the fiscal spending rule as a guideline for the conduction of fiscal policy.⁶ And as the Minister of Finance in Norway at the time, K. E. Schjøtt-Pedersen claimed, this premium was necessary to ensure a stable exchange rate while phasing in the revenues from the petroleum sector, as increased fiscal spending results in higher domestic wage growth.

Norges Bank is responsible for the implementation of monetary policy in Norway. They decide on their main policy tool, the key policy rate, that is normally set six times a year with a goal of stabilizing inflation close to the inflation target in the medium term (Norges Bank, 2017b). The rationale behind setting the key policy rate with a medium term horizon is that monetary policy affects inflation with a long and variable lag (K. Olsen et al., 2002). As a result, Norges Bank sets the key interest rate with a forward-looking and cautions approach where expectations are anchored around the forecast published in the Monetary Policy Report (MPR). The MPRs are published four times a year, coinciding with the monetary policy meetings in March, June, September and December.

2.2 The Inflation-targeting Framework

The inflation-targeting monetary policy framework were pioneered over two decades ago in New Zealand as a means of achieving low and stable inflation. It is thus a novel approach to monetary policy. Consecutive to the successful experience of many countries during the 90s and 00s, the popularity of the inflation-targeting framework has risen steadily. Today, more than 60 central banks conduct monetary policy by following an explicit inflation-target (Triami Media BV, 2017). With the exception of Finland, that joined the Eurosystem in 1999, no country that has introduced the inflation targeting framework has abandoned it (Norges Bank, 2017a).⁷

⁶The fiscal spending rule states that the structural, non-oil budget deficit shall correspond to the annual real return of The Government Pension Fund Global, estimated at four percent (Norges Bank Investment Management, 2014).

⁷Note that the European Central Bank (ECB) also follows an inflation targeting framework, where the main objective is to maintain price stability in the Euro area. Price stability is defined as an annual rate of increase in consumer prices below, but close to 2 percent over the medium term. Consequently, Finland

As emphasized by Hammond (2012), the inflation targeting framework is not a rigid set of rules, but rather a policy framework anchored around the inflation target. The framework is best summarized by the following characteristics (Hammond, 2012):

1. Price stability is explicitly recognized as the main goal of monetary policy.⁸
2. There is a public announcement of a quantitative target for inflation.
3. Monetary policy is based on a wide set of information, including an inflation forecast.
4. Transparency.
5. Accountability mechanisms.

Hammond (2012) argues that the major advantage of inflation targeting is that it combines elements of both ‘rules’ and ‘discretion’. King (2005) noted that ‘an inflation-targeting framework combines two distinct elements; A) a precise numerical target for inflation in the medium term, and, B) a response to economic shocks in the short term. The inflation target provides a rule-like framework on which the private sector can anchor its expectations about future inflation. Within this rule-like framework, the central bank enjoys some discretion in terms of reacting to shocks, for example in how quickly to bring inflation back to target (Hammond, 2012). Hence, in the event of a shock that is remarkably large, the policymakers may argue for a slower return than normally found reasonable. The reason for this is that a policy for a rapid return to the target could generate undesirable and devastating fluctuations in the real economy. Escape clauses of this type mean that the central bank does not focus solely on inflation when setting its policy rate and can thereby be seen as another way of expressing what we think of as flexible inflation targeting (Walsh, 2009).

The guidelines for Norwegian monetary policy is given by the three criteria for appropriate key policy rate path (Norges Bank, 2017a), and emphasizes that Norges Bank follows a flexible inflation-targeting framework:

1. The inflation target is achieved.
2. The inflation-targeting regime is flexible.
3. Monetary policy is robust.

The first criterion states that the key policy rate should be set in order to stabilize inflation

only technically abandoned the policy framework when they joined the Eurosystem controlled by the ECB.
⁸Although price stability is the primary objective, it is common for the mandate to include subsidiary objectives for economic growth and employment (Hammond, 2012).

at the target, or bring inflation back to the target after a deviation has occurred. I.e., the target is forward-looking, where expectations towards future inflation development are just as important as the current inflation level. The second criterion specifies that the key policy rate path should provide a reasonable balance between the path for expected inflation, and the path for expected overall capacity utilization in the economy. Together, the first two criteria are the foundation for the inflation-targeting framework, where the Bank's main objective is to provide a nominal anchor ensuring stable price development, but when achieved, the Bank would trade off fluctuations in inflation against fluctuations in real economic activity. For example, for prolonged periods in the wake of the global financial crisis, the inflation level has been well below the target, implying a clear tendency by the Bank to migrate business cycle fluctuations (Norges Bank, 2017b).

The third criterion implies that the path for the key policy rate should also take into account particularly adverse economic outcomes. In Norges Bank's guidelines for an appropriate key policy rate path, the third criterion states that monetary policy should be robust across the economy. Among other objectives, monetary policy should seek to mitigate the risk of financial imbalances (Ø. Olsen, 2014). The consideration of robustness may also imply a more active monetary policy than normal during periods when the economy is subject to major shocks (Norges Bank, 2016).

To achieve a reasonable balance between the various monetary policy considerations, Norges Bank argues that a sufficiently long and flexible horizon for the inflation target is needed (Norges Bank, 2017b). When the inflation targeting framework was officially introduced in 2001, Norges Bank decided the key rate on a horizon that "normally extended over two years". Later, in the Bank's first inflation report in 2005, the inflation target was changed into "a reasonable time horizon, normally one- to three-years" (Bruce and Sveen, 2017) (Norges Bank Watch, 2017). Two years later, in 2007, the Bank finally revised the criterion again, where the normal horizon of one- to three-years was removed. Instead, the current mandate of Norges Bank says that "the interest rate should be set with a view of stabilizing inflation close to the target in the medium term" (Norges Bank, 2017a). These changes in the objective of the Bank are similar to the developments among other inflation-targeting central banks, where the inflation-target is reached with a prolonged and more flexible time horizon (Bruce and Sveen, 2017). Regardless of these changes in the horizon for the key policy rate setting, the inflation expectations have remained well anchored around the target (Norges Bank, 2017a).⁹

⁹Survey-based inflation expectations display that the five-year horizon inflation expectations have shown little variation since 2001. Moreover, according to Norges Bank, the expectations series have no statistically significant relationship with current consumer price inflation, indicating that expectations are firmly anchored at the target.

The first two criteria represent a trade-off that Norges Bank has to consider when deciding on the key policy rate. Such considerations between output and inflation are expressed mathematically in terms of a loss function, where the parameter λ denotes the relative weight put on output deviation (Norges Bank, 2011):

$$L_t = (\pi_t - \pi_t^*)^2 + \lambda(y_t - y_t^*)^2 \quad (1)$$

The loss function in Equation (1) illustrates that the objectives of inflation targeting framework is approximated by a quadratic loss function consisting of; 1) the sum of the square of inflation deviations from the target, and, 2) a weight parameter, λ , times the square of the output gap. In practice, the weight given to stabilize output is likely to vary over time, where a larger value of the parameter λ implies a greater weight put on minimizing the output gap, at the expense of stabilizing inflation. This extends the time horizon for achieving the inflation target. Moreover, the size of the lambda is also likely to depend on the credibility of the central bank; when a central bank is trying to establish credibility, a greater weight is put on stabilizing inflation. Vice versa, a central bank that enjoys a large degree of credibility can put less weight on the inflation target, and hence, focus their policy towards other objectives (e.g. output deviation).

Further, to make an scholarly attractive overview of the robustness considerations made by the Bank, Norges Bank included the robustness criterion in an extended loss function in MPR 1/12:

$$L_t = (\pi_t - \pi_t^*)^2 + \lambda(y_t - y_t^*)^2 + \gamma(i_t - i_{t-1})^2 + \tau(i_t - i_t^*)^2 \quad (2)$$

The third criterion is reflected by the last three terms on the right hand side of Equation (2). In addition to minimize the output gap, Norges Bank seeks to avoid large changes in the key policy rate. Norges Bank argues that large deviations from one period to the next might create undesirable and prolonged imbalances in the economy (Nicolaysen, 2011). Therefore the Bank seeks to avoid large unexpected changes in the key policy rate. The last term on the right hand side of Equation (2) displays that there is a loss associated with the key policy rate deviating from its neutral level.¹⁰ Thus, the last term implies that Norges Bank aims to migrate the risk of buildups leading into financial imbalances. The rationale for such consideration is that low interest rates for extended periods can increase the risk that debt and asset prices will rise and remain higher than what is sustainable over the economic cycle (Jordà et al., 2011). However, Norges Bank stopped presenting

¹⁰The neutral interest rate is the real interest rate associated with growth equal to trend growth and stable inflation. A real interest rate equal to the neutral interest rate implies that monetary policy is neither expansive nor contractionary.

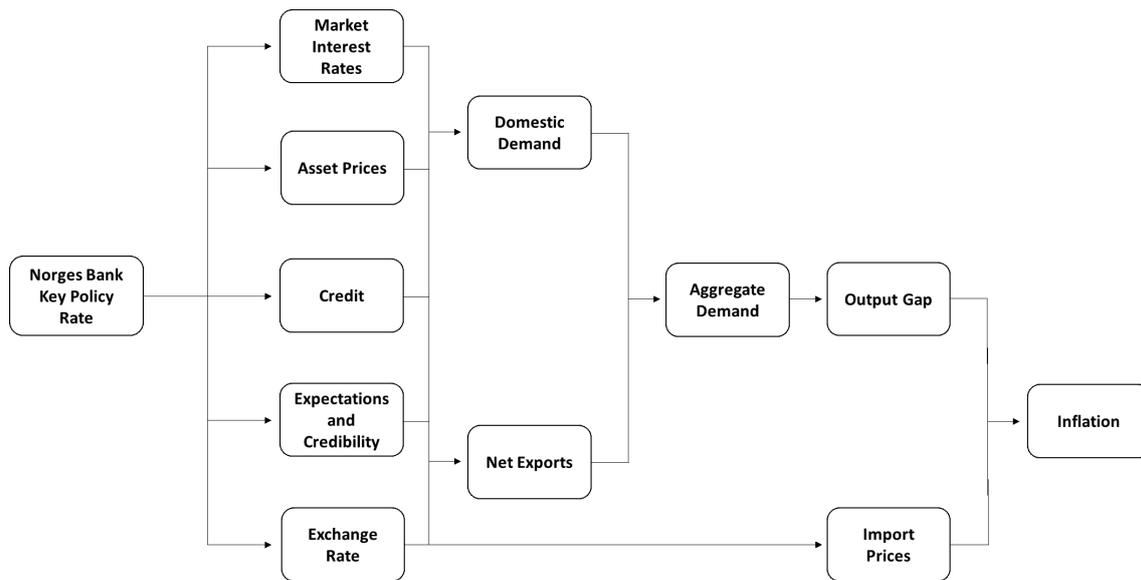
the third criteria in MPR 3/13. Unarguably, one possible explanation could be that the Bank do not want to appear bound by strict policy rules. In addition, the robustness-criterion is rather complex for the average agent in the economy, and one can argue that the considerations done by the Bank cannot be captured by simply adding two terms into the simplified loss function in Equation (1). Nevertheless, the extended loss function in Equation (2) yields a attractive theoretical illustration of Norges Bank's reaction pattern when shocks occur in the Norwegian economy.

In the aftermath of the global financial crisis, there has been a debate among academics and central bankers regarding whether policymakers should consider the risks associated with the buildup of financial imbalances. Reinhart and Rogoff (2009) provide a theoretical centered view, where they argue that the consequences of not considering these buildups during booms could be devastating. Building on Reinhart and Rogoff's research, Eichengreen et al. (2012) argues that the conventional relationship between price stability and other macroeconomic considerations need to be redefined by taking financial stability concerns into account when deciding on the policy tool. According to Pisani-ferry and Ramos (2011), monetary policy should consider financial stability risks in a similar fashion as the inflation considerations. In contrast to such view, Svensson (2012) argue that macroprudential regulation is better equipped to prevent financial imbalances building up in the economy. Hence, he believes that monetary policy is conducted favorably without taking stability concerns into consideration when deciding on the policy rate. With a view in between, Woodford (2011) and Smets (2014), argue that central banks should consider the complete economic picture. Following Woodford and Smets, Norges Bank argues that monetary policy should "lean against the wind", implying that the Bank view the costs of financial imbalances as large (Ø. Olsen, 2014). In addition, such view signals that the Bank disagree with Svensson (2012), viewing their toolbox as sufficient to consider the buildup of financial imbalances.

2.3 The Monetary Policy Transmission Mechanism

Changes in the key policy rate affect output and inflation through various channels. In the monetary policy literature, this is referred to as the transmission mechanism of monetary policy. Through the impact on short-term interest rates, monetary policy is managed in order to stimulate or slow aggregate activity in the short and intermediate term. In the longer term, interest rates and (long-run) expectations determines inflation (Hellum and Kårvik, 2012). What makes the transmission mechanism a complex and interesting field of study is the fact that monetary policy operate through multiple channels. Graphically, the conceptual relationship between the various channels can be expressed by the illustration

in Figure 2.1.



Note: For simplicity, the figure does not show interaction between variables.

Source: Pétursson, 2001

Figure 2.1: The Transmission Mechanism of Monetary Policy.

Norges Bank’s main monetary policy instrument is the key policy rate, which is the interest rate on banks’ deposits up to a given quota in Norges Bank. A change in the key rate influence short-term money market rates. From there, the policy change proceeds through one or more of the transmission channels described over the consecutive sections, and thereby influencing real activity before culminating in reduced or increased price pressure. In addition to changing the key policy rate, Norges Bank can intervene in the foreign exchange market in order to influence the NOK exchange rate. However, the Bank views interventions as an inappropriate instrument for influencing the Krone over a longer period, and as a result, Norges Bank has not intervened in the foreign exchange market since January 1999.

In the following discussion, we take it as given that the monetary authority’s policy instrument dictates the short-run interest rate. We also assume nominal wage and price rigidities, implying that changes in the nominal policy rate affect the real interest rate in the short and intermediate term. Consequently, our review of the effects from policy changes to real activity concentrates on how the short-term nominal policy rate proceeds via the real interest rate into the aggregate demand. Furthermore, we emphasize that it is the entire expected path of the interest rates, and not merely its current value, that influences the aggregate economy. Both considerations give rise to the role of expectations when assessing the monetary policy actions, as policy changes and communication can af-

fect both the expected course of nominal interest rates and the inflation outlook, yielding a direct effect on real interest rates (Boivin, Kiley, et al., 2010).¹¹ Indeed, Woodford (2003) argues that the monetary authority should provide guidance to the agents of the economy, and that the management of expectations is a key responsibility of the monetary authority.

Finally, we emphasize that the following discussion is restricted to the *common reactions* in the economy to changes in the central bank policy rate. In each case, the ultimate effect is determined by whether the adjustment is anticipated or not, in addition to its effect on expectations about future interest rate development. The economy may therefore display different responses from one time to another, depending upon circumstance surrounding each policy change (Pétursson, 2001).

2.3.1 Interest Rate Channel

Within the interest rate channel, which is often regarded as the main transmission channel of monetary policy, the policy decisions affect short-term nominal interest rates and, through sticky prices and rational expectations, the long-term nominal interest rates (John B Taylor, 1995; Loayza and Schmidt-Hebbel, 2002). In the case of a monetary restriction, short-term, and subsequently, longer-term interest rates increase. Following the assumption of temporary price-stickiness, this transmits into an increase in the real interest rates. The increase in real interest rates, through the higher cost of funds, causes a decline in investments (i.e., business fixed investments, residential housing investments, and inventory investments) and consumption that spreads into a decline of aggregate output and, consequently, a dampened inflation pressure (Galí, 2015).

A change in the central bank policy rate has an immediate impact in the money market (the market for securities with maturity from one day to one year) (Bank of England Monetary Policy Council, 1999). A rise in the policy rate leads on average to an immediate rise in the interbank and other short-term money market rates, although not necessarily by the same magnitude; by definition, this depends on the securities' maturity compared to the instrument priced by the policy rate, and how actively the instrument in question is traded (Pétursson, 2001). Interest rates on banks' short-term instruments should rise immediately, since they are normally financed to a large extent in these markets, whereas interest rates on short-term variable-rate loans rise subsequently (Pétursson, 2001). Rates

¹¹Curiously, with nominal interest rates close to the zero nominal lower bound, the role of expectations provides an increasingly important mechanism in which monetary policy can stimulate aggregate demand. In particular, a credible commitment to continued future expansionary monetary policy can lower long-term interest rates and raise expected inflation, thereby lowering real interest rates and stimulate the economy (Woodford, 2003). For example, the FED has indicated for a prolonged periods since the global financial crisis that the federal funds rate would be kept close to zero for an extended period.

on short-term fixed-rate instruments also hike, but in general with some lag. Monetary policy generally does not have much effect on the spread between lending and borrowing rates, so deposit rates should follow the policy rate hike (Pétursson, 2001).

The impact of a policy rate change on long-term nominal rates is not as obvious as on short-term rates. A higher policy rate may cause either a rise or a fall in long-term interest rates, since these rates are determined by the average of current and expected future short-term interest rates across the maturity of the instrument (Gerlach and Smets, 1995). Consequently, the response on longer term interest rates depends on the effect that the policy rate hike has on market expectations about future developments of short-term rates, and especially about future inflation developments, which are the key determinant of nominal interest rates (Rudebusch, 1995). To illustrate, if market participants anticipate short-term interest rates to fall considerably in subsequent time, long-term interest rates could even fall in response to a policy rate rise. Such expectations might reflect, for example, confidence that the policy rate hike is satisfactory to prompt a considerable reduction in the future inflation rate (Pétursson, 2001). Conversely, if market expectations view the policy rate rise as the first out of many hikes, this may shift the long-term interest rates upwards by more than the change in short-term rates.

2.3.2 Asset Price Channel

A central bank policy rate change also affects asset prices, e.g. equity and housing prices. In general, a decline in the policy rate leads to an increase in equity prices, as the associated income stream is now discounted at a lower rate than before the hike.

As noticed in Bjørnland and Jacobsen (2010), housing has a twofolded role of both being a store of wealth and a durable consumption good. Hence, expansionary monetary policy might raise household wealth, which again raises consumption spending and aggregate demand. In addition, house prices influence banks' balance sheets. If real estate prices rise due to a monetary expansion, banks' loan losses may decrease, which increases bank capital and thus lending. Therefore, accommodative monetary policy may raise both the supply and demand for credit, which will raise asset prices even further. Consequently, there may be a feedback loop between eased financial constraints and rising asset prices, which is referred to as the *financial accelerator* mechanism in Bernanke, Gertler, and Gilchrist (1999). Vice versa, Meltzer (1995) points to the fact that contractionary monetary policy could have an important impact on the target variables through its effect on property prices. A contractionary monetary policy, causing declining prices, transmits into decreasing household wealth, and a consequent decrease in consumption and aggregate output.

Furthermore, Mishkin (2001) illustrates the asset price mechanism by the *Tobin's q theory*. Tobin (1969), a Nobel laureate in economics, proposed that firms base their investment decisions on the following ratio:

$$Tobin's\ q = \frac{Market\ Value\ of\ Capital}{Replacement\ Cost\ of\ Capital} \quad (3)$$

The *q theory* is defined as the market value of firms divided by the replacement cost of capital. In the case of a monetary policy contraction, increasing interest rates imply decreasing bond prices. Lower bond prices yield relatively more attractive fixed income securities compared to equities, causing a flight from equities into fixed income. The snowball effect yields falling equity prices that, according to the theory, decreases *q*. And, according to Tobin, a lower *q* induces lower investments and aggregate output in the broad economy.

Finally, based on the ideas of the *life-cycle hypothesis* introduced by Modigliani (1966), the policy effect on private wealth through the asset price channel could be substantial. According to the theory, which focuses on stocks as a component of private wealth, the lifetime resources of consumers determine consumption spending. Furthermore, since stocks are a significant share of the financial wealth, falling stock prices caused by contractionary monetary policy thus lead to falling financial wealth that transmits into decreasing lifetime resources and contracting consumption (Case et al., 2005; Elbourne, 2008)

2.3.3 Credit Channel

Asymmetry in the credit markets result in a wedge between the costs of external funds (i.e. from banks and other lenders) to the public, and the cost of internal funds. Thus, internal funds, bank loans and other sources of financing are imperfect substitutes for firms. These imperfections related to credit market frictions cause monetary policy changes that affects both the bank-lending channel and the balance sheet channel (Gertler and Bernanke, 1995).

The bank-lending channel underpins the role of banks as financial intermediaries, as their business structure is designed to serve small to mid-sized enterprises and households, where the problem of asymmetric information emerges (Stiglitz and Weiss, 1981). According to the theory, an increase in interest rates causes a contraction in bank reserves and bank deposits, which transmits into a tightening of intermediate credit. Thus, the reduction in the supply of bank credit, relative to other forms of credit, increases the external finance premium and contracts real activity (Bernanke and Blinder, 1988; Gertler and Bernanke, 1995).

Similar to the bank lending channel, the balance sheet channel emerges from the asymmetric information-problem in credit markets. When the net worth of an agent falls, adverse selection and moral hazard problems increase in credit markets (Boivin, Kiley, et al., 2010). More specifically, contractionary monetary policy decreases the net worth of agents and firms, implying less collateral for the loans, and consequently, increased losses due to the adverse selection. This again tends to cause more reluctant lenders, evident by their demand for higher risk premiums and reduced lending volume, causing a decline in spending and aggregate demand (Bernanke and Gertler, 1989; Bernanke, Gertler, and Gilchrist, 1999). Beyond this asymmetric information problem, the lower net worth of firms devalue owners' equity stake in their firms implying increased risk appetite. Again, this causes a decrease in the loan supply and thus a decrease in aggregate output. Furthermore, increased interest rates transmits into a higher debt burden for loans with floating interest rates. The increase in interest rates suggests that the cash flow of firms and households weakens, leading to decreasing investments and consumption.

A recent line of research discusses the link between monetary policy, especially in prolonged periods of low interest rates, and higher levels of risk-taking by banks (Borio and Zhu, 2012). The risk-taking channel is thought to operate via three main mechanisms. First, the search-for-yield mechanism, with low (nominal) interest rates increasing incentives for banks to take on more risk (Rajan, 2005). The second mechanism relates to the impact of low interest rates on real valuations, incomes, and cash flows. Low rates boost asset and collateral values while tending to reduce price volatility, which in turn downsizes the banks estimated probability of default. Hence, yielding in a belief that the increase in asset values are sustainable, encouraging both borrowers and banks to accept higher risk positions (Borio and Zhu, 2012). Third, monetary policy also affects risk-taking through the reaction function of the central bank to negative shocks. In theory, the commitment of a central bank to both decide and communicate lower interest rates in response to a sizable shock reduces the downside risk, and thereby encourages financial institutions to accept greater risk.¹²

The credit channel theory implies that monetary policy has real effects through credit supply and demand. However, these changes are mostly unobserved, implying a challenging identification of the credit channel and its sub-channels (Ciccarelli et al., 2015).

¹²This effect, popularly nicknamed the Greenspan- or Bernanke-put, run through the *expected* lower interest rates rather than the *current* low rates themselves. Its magnitude, however, depends on the current level of the policy rate. Anticipated reductions in the interest level tend to correspond to higher risk position when there is room for a monetary expansion (De Nicolo and Lucchetta, 2010).

2.3.4 The Exchange Rate Channel

What happens to exchange rates when the key interest rates are changed? In general, increased domestic rates provides an incentive to invest in the domestic currency relative to foreign currencies, resulting in the inflow of funds into the domestic currency, causing the domestic currency to appreciate.

Specifically, exchange rate changes will typically influence inflation through three inter-linked channels (Haan et al., 2012). First, exchange rate movements affect the domestic price of imported goods directly. If the exchange rate appreciates, the price of imported goods tends to fall, insofar as these goods are used in consumption directly. Second, if these imports are used in the production process as inputs, lower prices transmits into lower prices for final goods. However, due to stickiness in prices these effects generally operates with a lag. Third, an appreciation in the exchange rate may also have an effect via their impact on the competitiveness of domestically produced goods on international markets. Hence, the exchange rate appreciation causes domestically produced goods less competitive, and by that, tends to curb external demand. Consequently, the overall effect is reduced demand pressure in the economy. Thus, *ceteris paribus*, an appreciation of the exchange rate would reduce the inflationary pressure (ECB, 2011). However, the strength of exchange rate effect depends on the openness of the economy. In general, exchange rate effects are less important for larger economies than for smaller economies (such as Norway) (Batini et al., 2003).

On the other hand, a rise in nominal interest rates reflecting higher inflation expectations generally causes the domestic exchange rate to depreciate. By example, investors who are expecting higher future inflation would reduce its domestic forex portfolio. If this increased supply of domestic currency exceeds the inflow, the exchange rate will depreciate. Hence, a rise in the key policy rate may therefore weaken the domestic exchange rate if higher inflation expectations overshoots the policy hike (Pétursson, 2001).

2.3.5 Expectations and Confidence Channel

There can be no doubt that the prevailing monetary policy framework is founded on forward-looking and rational economic agents, where the expectation channel is in effect fundamental to the working of all channels of the monetary policy transmission mechanism. Principally, the expectations channel influences the private sector's long-term expectations by impacting the perception of households and firms regarding intertemporal rates of substitution. Specifically, agents shape their expectations from past monetary policy decisions, developments in key macroeconomic variables and the communication from the

central bank (Woodford, 2005). Assuming that these agents are maximizing their current and future consumption and investment, expectations affect their current aggregate output. For example, inflation expectations play an important role by influencing interest rates, exchange rate movements, wages, aggregate demand, and domestic prices (John B Taylor, 1995).

The role of expectations has gained particular relevance for the conduct of monetary policy over past decades where its effectiveness hinges on the credibility of the central bank, i.e., the correlation between the central bank communications and actions (Woodford, 2003). For instance, if the central bank possesses a high degree of credibility (i.e., a high λ in the aforementioned loss function) in pursuing its target, monetary policy can effectively influence price developments by managing expectations of future inflation, and thereby, influence the agents' wage and price-setting (ECB, 2011). Furthermore, there are considerable theoretical and empirical works about the impact of inflation targeting credibility on inflation, inflation expectations and short-term interest rates.¹³ All of them suggest that an inflation targeting regime with high credibility implies less volatile future interest rates and better anchored inflation expectations. Thus, if economic agents view the central bank's commitment to maintain price stability as credible, (long-term) inflation expectations should remain fairly well anchored to the inflation target. In this respect, credibility facilitates and underpins the objective of monetary policy.

In general, a rise in the policy rate would be viewed as signal to slow down the economy in order to achieve the inflation target, with future growth prospects deteriorating and inflation expectations falling if the policy action is credible (Pétursson, 2001). However, if the central bank lacks credibility, i.e. if the agents of the economy interpret the bank's efforts to slow down the economy as inadequate, expectations of further interest rate hikes could arise, and thereby, magnifying the contraction impact. A higher policy rate could also be interpreted as reflecting that the bank views that the economy is growing faster than had earlier been thought, thereby spurring future growth expectations and by that, reducing the aggregate tightening imposed by the monetary policy rate hike (Pétursson, 2001)

¹³See Kydland and Prescott (1977) and Blanchard (1985) among others.

Literature Review

The current literature on the monetary policy transmission mechanism is rich and continually expanding. During the last three decades, numerous methodological approaches have been applied in order to further understand both the effect and the extension of monetary policy. Among other, a reader would find papers based on Dynamic Stochastic General Equilibrium (DSGE) models, Vector Autoregressions (VARs), Structural VARs, and Factor-augmented VARs. Most of these papers focus on the transmission mechanism in large advanced economies. However, the literature on the monetary policy transmission mechanism in the Norwegian economy is rather limited, where previous work is centered on the role of house prices and credit (Bjørnland and Jacobsen, 2010; Robstad, 2014), and the exchange rate (Bjørnland, 2008).

In this section, we provide a detailed literature review of the empirical and theoretical studies concerning the estimation and the transmission of a monetary policy shock.

3.1 The Vector Autoregression

Following the seminal work by Sims (1980), the Vector Autoregression (VAR) has evolved to become the workhorse methodology in analyzing monetary policy shocks. The recurrent employment of the VAR methodology in the monetary policy literature is due to its simplicity and straightforward model specification. In detail, as elucidated in Bernanke, Boivin, et al. (2005), by utilizing this method we are able to identify dynamic responses of variables important to monetary policy without the need to estimate the entire macroeconomic model (contrary to e.g. the DSGE/large-scale macroeconometric models).

Parallel to increased academic insight in the monetary policy transmission mechanism, the VAR methodology has been further developed by among others Gerlach and Smets (1995), Leeper et al. (1996), and Christiano et al. (1998). The last-mentioned citation provides a detailed evaluation of the literature on the monetary transmission mechanism in the U.S. Similarly, there has been extensive studies in Europe to examine various channels of monetary policy transmission in the Euro area countries (Angeloni et al., 2003).¹⁴

Despite the advantages associated with the VAR framework, the methodology has not developed without criticism. During its lifetime, there have been extensive discussions among practitioners, where, most notably, the methodology used to identify monetary

¹⁴The research on monetary transmission in the Euro area focuses either on Euro area-wide analysis (Peersman and Smets, 2001), or more detailed studies of specific countries (Mojon and Peersman, 2001).

policy shocks has been the most attacked steppingstone. Christiano et al. (1998) present an extensive discussion of the different identification schemes existing in the literature, where the authors identify three general strategies in order to isolate monetary policy shocks. And, as outlined in their paper, the choice of identification method has specific implications for the results of the analysis. However, due to the scope of our thesis, the VAR approach is the focus for identifying shocks in our analysis.¹⁵

The VAR methodology for isolating monetary policy shocks involves making enough identifying assumptions so that the monetary policymakers' feedback rule can be estimated.¹⁶ Following Christiano et al. (1998) the common method is to adopt the recursive hypothesis, in which the monetary policy shock is orthogonal to the information set utilized by the monetary authority. Subsequent to this assumption, the variables included in the VAR needs to be classified into three groups. The first group contains the variables that comprise the information set of the monetary authority, and that respond to a policy shock with the delay of at least one period. The second group includes only the monetary policy instrument, whereas the third group consists of the variables that responds contemporaneously to the shock.

Although being frequently adopted, the recursive hypothesis following the VAR framework limits the existence of simultaneity in determining the model variables. As a consequence, numerous studies have utilized the structural VAR (SVAR), abandoning the assumption that the monetary authority only consider economic factors that are predetermined to the monetary policy shock. However, by utilizing such methods, it is no longer possible to isolate the shock using OLS. Hence, it becomes necessary to make other assumptions in order to estimate the monetary policy shock. Bernanke, Boivin, et al. (2005) explains that some studies impose contemporaneous restrictions, i.e., matrix restrictions that relate the structural shocks to the VAR error term, while others impose restrictions on the impulse response format for extended horizons. Even though the SVAR framework solves the simultaneity problem, its identification schemes have been criticized. One of the most common critiques are that contemporaneous restrictions are arbitrary, as there is no academic consensus on which one(s) should be adopted. Furthermore, long-term restrictions are heavily criticized for not always generating theoretically plausible results for short-run dynamics.

¹⁵See for example, Romer and Romer (1989) for the second strategy, involving examination of FED's policy considerations to identify monetary policy shocks. Furthermore, the third strategy identifies monetary policy shocks by the assumptions that they do not affect economic activity in the long run. For an example of this approach, see Gali (1992).

¹⁶An illustration of such feedback rules is the *Taylor rule* (John B. Taylor, 1993). In its purest form it relates the level of the key policy rate to the key monetary policy variables, namely the output and inflation gap.

The key issue with the VAR methodology is that results obtained are not consistent with the established theoretical rationale, with the *price puzzle* being the main recurrent problem. Following the theory outlined in Section 2.3, output and prices should temporarily decrease after monetary contraction. However, the observed result in many VAR studies is that, on a contrary, a contractionary monetary shock is followed by increased inflation.¹⁷ Sims (1992) explain the price puzzle by the fact that the VAR does not include information that captures future inflationary pressure. Following the argument of Sims, the contractionary shock should then be a response to this pressure and, as such, studies are only able to partially contain the future increase in price levels using the VAR framework. However, some studies, such as Sims (1992), Bernanke and Mihov (1998) and Christiano et al. (1998) indicate that one can dampen the price puzzle by including commodity prices.

In addition, an extensive set of literature reviews the monetary policy effect on the exchange rate. Generally, the uncovered interest rate parity suggests that after a monetary tightening the exchange rate would appreciate, before gradually depreciating following the dampening monetary policy effect. However, empirical evidence is somewhat mixed, where some studies find a rather persistent appreciation of the domestic currency, known as the *delayed overshooting puzzle* (Eichenbaum and Evans, 1995), while other studies report that the exchange rate consistently depreciates with monetary policy contraction (Kim and Roubini, 2000)

The next critique relates to the fact that the VAR methodology only considers unanticipated changes in monetary policy. As extensively discussed in Sims and Zha (2006), most policy actions are *systematic*. That is, the actions conducted by the policymakers' are systematic responses to variations in the state of the economy.¹⁸ However, the VAR framework does not acknowledge this systematic component of monetary policy, and therefore underestimates the entire effect.

Building on the aforementioned critiques, a number of studies have stressed the potential

¹⁷The term *price puzzle* was introduced by Eichenbaum (1992). Bjørnland and Jacobsen (2010), Robstad (2014) finds evidence in favor of a price puzzle using two different model specification for quarterly Norwegian data spanning from Q1:1994 to Q4:2013.

¹⁸Christiano et al. (1998) highlights that the systematic component is typically formalized by estimating a reaction function, and that the equation error that relates it to the policy instrument is usually considered the shock. The literature refers to three main ways to interpret these shocks; 1) as a preference shift on the part of the monetary authority, as exemplified by a change in political power or monetary objective, causing an alteration in the relative weights of the variables in the reaction function, 2) Ball et al. (2005), and Chari et al. (1998), discuss the monetary authorities' tendency to avoid the social costs of altering the agents expectations. Thus, they argue that changes in these expectations can lead to an exogenous shock. 3) A monetary shock is the effect of measurement errors in the series used for decision-making (Bernanke and Mihov, 1998; Hamilton, 1997).

model misspecification related to monetary policy shock identification. For example, Brissimis and Magginas (2006) finds that adding forward-looking variables, such as market traded federal funds futures to the VAR model, yields economic intuitive responses. The authors argument for including futures is that the instrument contains expectations about future monetary policy actions. This expectation element may also be found to a certain extent in commodity prices, which explains why including such series partly eliminates the price puzzle elaborated on prior in this section Sims (1992).

Moreover, Croushore and Evans (2006) emphasize the role of data revisions in identifying monetary policy shocks. Doubtless, monetary policy makers react to the information set available at the time of decision-making. However, GDP data, among others, is normally revised after some time, resulting in potential biases in the estimated monetary policy effects. Also, monetary policy makers, evident from policy minutes and communication, often tend to react to the output gap rather than GDP growth rate. A study by Giordani (2004) shows that replacing the GDP growth rate with the output gap reduces the effect of the price puzzle.

Although there exists theories that justify the aforementioned counterintuitive relationships, one must consider the key drawback of using the VAR methodology, as stressed by Sims (1992), to be the limited use of information. Reports, papers, and communication from the monetary authorities indicates that an inflation targeting central bank uses a very broad information set in their decision making. This is in accordance with the influential Svensson (2002), who expresses that the system of inflation targeting is based on an extensive process that requires thorough analysis of a large information set, rather than being mechanical decision regarding the policy rate level. Furthermore, in Bernanke, Boivin, et al. (2005), Ben Bernanke the former Chair of the Federal Reserve, emphasizes that the FED monitors hundreds of variables in its decision-making. Although most of them are excluded in the central banks' reaction function, they provide crucial indications of the variables that are directly considered in the decision-making. As emphasized by the authors, the costs of policymakers to obtain and analyze such a wide range of information underpins the importance of a rich information set when aiming to align central bank practices and academic analysis.

The simple VAR specification offers great simplicity and tractability, and is as such attractive when attempting to characterize the determinants and effects of monetary policy (Bernanke, Boivin, et al., 2005). However, the preservation of degrees of freedom requires that the VAR only include a reduced number of variables, which shapes a difference between central bank practice and the methodological approach (Soares, 2013). Therefore, it is unlikely that the model captures all of the information analyzed by the policymakers.

Thus, the results obtained using this methodology indicates that the omission of relevant variables can cause biased estimates. In particular, the systematic component of the monetary policy changes can be confused with the shocks, resulting in dynamic responses that do not reflect the actual underlying economy's response to a monetary policy shock.

3.2 The Factor-augmented VAR

A fairly recent stance of leading macroeconometricians suggests that in order to better capture the dynamics of the economy, significant advantages arise from employing models specifically designed to handle large information sets. The so-called *dynamic factor models* allow us to summarize the information contained in a large number of data series in a smaller number of estimated factors. In empirical macroeconomics large-dimensional dynamic factor models have become popular in recent years, but the literature on dynamic factor analysis employed in economic research goes back to Geweke (1977) and, Sargent and Sims (1977).

Mainly two estimation methods are currently practiced in the estimation of dynamic factor models, namely the *principal component analysis method*, and the *maximum likelihood approach*. In the principal component method, the literature separates two approaches for extracting information. The first approach, dating back to Stock and Watson (1998; 1999; 2002b; 2002a), extracts factors by static principal components, while the second approach relies on dynamic principal component.¹⁹ For the usage of the maximum likelihood estimator in monetary policy analysis, we refer to Doz et al. (2011), which provide a comparison of the maximum likelihood approach against the principal component.²⁰

Aiming to resolve the problems of the standard VAR, Bernanke, Boivin, et al. (2005) apply the Stock and Watson (1998; 1999; 2002a; 2002b) methodology to extract the factors in order summarize the information from a rich dataset, and then include those factors in the VAR model. The authors refer to their methodology as the *factor-augmented VAR* (FAVAR) approach, and suggest that factor models are a well-grounded solution to the degrees-of-freedom issue in the VAR analysis of monetary policy, as the methodology permits the consideration of a significantly larger information set without sacrificing the statistical benefits associated with restricting the model to a small number of regressors. Since the FAVAR can handle a large set of information, and thus reflect the broader information set monitored by monetary policymakers, the probability of a poorly specified econometric model in assessing the effects of a monetary policy shock significantly decreases. In the

¹⁹See Forni et al. (2000) for a extensive description of the dynamic principle component methodology.

²⁰For an in-depth review and a comprehensive list of earlier work on the different estimation methods, including Bayesian methods, we refer to Bai and Ng (2008).

paper, Bernanke, Boivin, et al. (2005) uses a dataset with 120 monthly macroeconomic series spanning from January 1959 to August 2001. Problems such as the price puzzle were reduced, further nourishing the argument presented by Sims (1992) regarding the limited use of information in the simple VAR model. Moreover, the FAVAR makes it possible to compute impulse responses to a contractionary monetary policy shock for each of the variables included in the dataset. Hence, contrary to the standard VAR methodology, we are able to examine the effect of a monetary shock on a broad set of variables across the economy.

Furthermore, a second advantage of the FAVAR methodology is that it is not necessary to specify a single series as a proxy for a theoretical concept. Bernanke, Boivin, et al. (2005) highlights an example of this improvement by the concept of "economic activity" not needing to be represented by the industrial production series or real GDP. Hence, the data series used is not exclusive, and others, such as employment, sales and other broad indicators can also be included. Consequently, by employing the FAVAR model we avoid arbitrary choices when specifying the model.

Bernanke, Boivin, et al. (2005) describes two alternative estimation procedures; a two-step method based on principal component analysis, and a second Bayesian method based on Gibbs sampling. In conclusion, the authors find that both procedures yielded qualitatively analogous results that are in line with well-established economic theories. However, they argue that the two-step principal components method tended to result in more economic plausible responses.

3.3 Results in the Empirical Literature

Initiated by the article of Bernanke, Boivin, et al. (2005), an abundant literature analyzes the impact of monetary policy shocks, and how the transmission mechanism of these shocks has evolved using the FAVAR methodology. Most of the studies are examining the U.S. economy or the large Euro area economies, whereas the literature on the Norwegian economy using the FAVAR methodology is to our best knowledge limited.²¹ In

²¹Aastveit et al. (2016) exploit a open economy Factor-augmented VAR to examine business cycle synchronization. The study focuses on how price and activity shocks in both the foreign and domestic economy transmits into (among others) the Norwegian economy. However, the study selects the Euro Area interest rate as the regional interest rate where the initial shock occurs, causing somewhat non-comparable results. Nevertheless, their result indicate that a one percentage point unexpected increase in the regional short-term interest rate (i.e. the Euro Area interest rate) has a significant negative effect on real activity. Further, inflation gradually falls with a long delay, while the exchange rate temporarily depreciates. Stock prices and housing prices fall strongly. However, these effects must be seen in relation to the subsequent monetary policy rate increase by Norges Bank in their analysis, implying a feedback effect between the

general, all studies conclude that adding estimated factors from the factor model to the VAR specification allows for a more solid analysis of monetary policy shocks.

In detail, Bernanke, Boivin, et al.'s results using three factors proved consistent with theory, where real activity measures such as GDP, industrial production and their associated components such as consumption and employment declined in response to a contractionary monetary policy shock. Further, consumer price indices move down after a (short) initial increase. Last, consistent with Tobin's q theory, asset prices and dividend yields move downwards, and the authors find little support for the overshooting hypothesis following Dornbusch (1976), where the exchange rate gradually appreciates in their FAVAR results.

Stock and Watson (2005) find that the estimated number of factors for representing the U.S. economy exceeds the three principal factors found in Bernanke, Boivin, et al. Using a two-step estimation method with principal components, they estimate the number of factors to be seven. Further, they find that a one percentage point increase in the Fed Funds rate led to dampening output and employment, where total employment fell by a half percent, while industrial production fell by a percent after one year. The stock market turns bear, with the S&P500 dropping 11 percent of its total market cap within six months. Similar to Bernanke, Boivin, et al., the authors find a persistent appreciation of the U.S. Dollar relative to the other major currencies. On the contrary, the authors find some curious features of the impulse responses. Particularly, the consumer price index (CPI) inflation rises by 20 basis points and does not appear to fall thereafter. Furthermore, the monetary policy contraction is associated with a temporarily steeper yield curve, which is in sharp contrast to macroeconomic theory.²²

3.3.1 Transmission of Shock in a Norwegian Context

While FAVAR studies of the Norwegian transmission mechanism is limited, earlier research have employed the SVAR methodology using Norwegian data more frequently. In 2008, Bjørnland examined the exchange rate channel of monetary policy, where she imposed a long-run neutrality restriction on the real exchange rate. After having allowed for full simultaneity between monetary policy and the exchange rate, she finds that a monetary policy shock implies a strong and immediate appreciation of the exchange rate. Thereafter, the exchange rate gradually depreciates back to the baseline, consistent with the Dornbusch overshooting hypothesis and broadly consistent with uncovered interest rate parity. Further, the monetary policy shock temporarily lowers output and employment, in regional shock and the policy response by Norges Bank.

²²The authors argue that these situations could be due to either; A) a statistical artifact, B) a feature readily addressed by modifying the dataset, or C) a fundamental flaw in the recursive identification scheme.

addition to sluggishly, although negatively, impacting consumer price inflation. However, she finds no evidence of the price puzzle.

Furthermore, the paper by Bjørnland and Jacobsen (2010) finds remarkable strong effects of monetary policy on real housing prices when employing short- and long-run identification restrictions to identify the monetary policy shock. In particular, by allowing both the interest rate and housing prices to react simultaneously to new information, the authors find that housing prices react immediately and strongly to a monetary policy shock. Specifically, a one percentage point increase in the key policy rate causes output to drop by one percent within the first year. Further, the effect on inflation is *eventually* negative, but, on the contrary to common theory, consumer prices increase initially, indicating the presence of a price puzzle. Housing prices fall contemporaneously by one percent, before falling further two percent within the next six to eight months.

Robstad (2014) extends Bjørnland and Jacobsen's VAR model by adding a credit variable. He motivates this extension by the role of credit measures in the indicators of financial stability, in addition to capture possible multidimensional links between credit, house prices and interest rates. Overall, his results support the finding in Bjørnland and Jacobsen (2010), concluding that housing prices react relatively strongly to a monetary policy shock. However, neither his specification removes the price puzzle, although the magnitude is reduced. His results are fairly robust across various identification assumptions, although the effect of monetary policy on housing prices is larger when simultaneous effects are allowed for in the model (Robstad, 2014).

3.3.2 Changes in the Monetary Transmission Mechanism

Another subsection of the literature addresses the question of whether the mechanism for the monetary policy transmission has changed over time and, if so, how. Such a change implies that some of the parameters in the model have changed over time, which means that there are changes in the correlation of the monetary policy instrument and the variable of interest (Boivin, Kiley, et al., 2010). In order to evaluate the existence and the importance of changes in the monetary transmission mechanism, past studies have used either of the following strategies, where they estimate an empirical model; A) over different subsamples, B) by treating some of the parameters as time-varying latent processes, or C) using regime switching models where the parameters can stochastically switch between different regime dependent values (Boivin, Kiley, et al., 2010). Summarized, the literature appears to be in agreement on the fact that this mechanism has changed, where, for example Boivin, Kiley, et al. (2010) argues that the changes in the monetary transmission mechanism is due to the more stabilizing policy regime. In particular, they find that the reduced effect

of monetary policy shocks in the post-1980 period is mostly explained by the increased responsiveness to inflation expectations by the FED.

Boivin and Giannoni (2006) estimated a VAR over two subsamples corresponding to the pre- and post-Volcker periods, (pre- and post-1980). They find that there is a reduction in the effect of monetary policy following a policy shock in the post-Volcker period, where responses in both output and inflation are more dampened in the latest subsample. The authors argue that the change in the volatility of the indicators is due to; A) the change in the conduct of monetary policy, with the post-Volcker period characterized by a stronger response to inflation, and hence inflation-expectations, and, B) a more effective systematic behavior of monetary policy (Boivin and Giannoni, 2006).

An example of the second strategy, which typically assume that the parameters follow a random walk, is the study by Primiceri (2005). An advantage of such a method relative to the subsample analysis is that it allows for precisely tracking the evolution of the coefficient over time. Based on a recursively identified VAR, the author examines the effect of U.S. monetary policy shocks on inflation and unemployment in three different sample time frames. These time frames represent the economic environment of the Burns, Volcker and Greenspan chairmanship. The results indicate minimal changes in the transmission of monetary policy over time. Canova and Gambetti (2009) came to similar conclusions using sign restrictions. However, there are some conflicting results between the two papers, where especially the two papers opposite effects for the post-1990 period are remarkable.

Further, Abbate et al. (2016) use a time-varying FAVAR (TV-FAVAR) model, where the factor loadings, factor dynamics, and the variance-covariance matrix of innovations vary over time, to analyze potential changes in the monetary transmission mechanism from 1972 to 2007 for the U.S. economy. The results indicate substantial time-variation in the volatility of monetary policy shocks, where the negative impacts following a monetary policy shock declined over this period. The authors also emphasize that the negative impact of a monetary policy shock on inflation expectations and long-term interest rates diminished over time. Analogous to Boivin, Kiley, et al. (2010), the authors argued that these progressions are due to changes in the monetary policy conduction, and the globalization of trade and finance.

For an example of the third strategy, namely the regime switching models, we refer to Huber and Fischer (2015), who exploits the FAVAR methodology to investigate the relationship between business cycle phases and monetary policy for the U.S economy between 1971:Q4 and 2014:Q2. Their results indicate that the effects of monetary policy are stronger in recessions, whereas the responses are more muted in expansionary phases.

Empirical Methodology

In this section of the thesis, we describe the econometric framework applied to analyze the monetary policy transmission mechanism of the Norwegian economy. Our FAVAR methodology follows Bernanke, Boivin, et al. (2005) in using the Stock and Watson (1998; 1999; 2002b; 2002a) static principal component analysis to extract factors from a rich dataset comprising 103 macroeconomic time series for the Norwegian economy.

As indicated in Section 3.2, the FAVAR model provides a fine-grained and elegant economic analysis on the effect of a monetary policy shock. To provide the reader with the econometric foundations for the FAVAR methodology, we first describe the VAR framework as developed by Sims (1980). Second, we outline the methodology used for estimating the factors and how the number of factors is determined. Finally, we present the complete FAVAR model and describe how the structural monetary policy shocks are recovered.

4.1 Vector Autoregression

A vector autoregression (VAR) of order p is a system of M variables in M equations, in which a variable y_t relates to p previous values of itself, and to p previous realizations of the other $M - 1$ variables in the system. In matrix form, a *reduced form* VAR model designed to analyze the transmission mechanism of monetary policy for the Norwegian economy can be expressed as follows:

$$Y_t = \phi_1 Y_{t-1} + \dots + \phi_p Y_{t-p} + e_t \quad (4)$$

with Y defined as the $M \times 1$ vector containing $M - 1$ macroeconomic variables and the monetary policy tool, for example the key policy rate. The coefficients, ϕ_i , are $M \times M$ matrices, and e_t is a $M \times 1$ vector of white noise innovations with contemporaneous covariance defined by the $M \times M$ matrix, \sum_e . Specifically, the innovation in Y_{it} is the one-step ahead forecast error, e_{it} , in the i^{th} equation.

In terms of monetary policy analysis, the $M - 1$ macroeconomic variables are intended to represent broad economic concepts such as "economic activity", "price pressure" or other concepts important for describing the dynamics of the economy. If the $M - 1$ macroeconomic variables are perfect proxies of the information assessed by the policymakers, the one-step ahead forecast error for key policy rate can be interpreted as an unexpected change in the key policy rate, i.e., a monetary policy shock. However, in order to estimate

the *causal* effect of a monetary policy shock, the innovations across equations must be uncorrelated. We therefore impose restrictions on how the *structural shocks* relate to the M variables in the VAR. The structural shocks are by definition white noise and uncorrelated across equations, and if these can be recovered as linear combinations of the innovations, we can estimate the causal effect of a monetary policy shock.

4.2 Factor Analysis

The attractiveness of dynamic factor models (DFM) pivots on their ability to use a relatively small number of factors to capture the co-movements in a rich set of information. Analogues to Stock and Watson (2002b), we distinguish between *exact factor models* and *approximate factor models*. Specifically, the exact factor models estimate the factors under the assumption that the idiosyncratic errors are uncorrelated across variables. As emphasized by Stock and Watson (2002b), this is an implausible assumption when working with macroeconomic series. Thus, we employ an approximate factor model that allows for some correlation between the idiosyncratic errors, as well a low degree of correlation between the idiosyncratic errors and the estimated factors.²³ In the literature, there is also made a distinction between the *static form* and the *dynamic form* of the DFM. In the latter, a factor can enter with leads and/or lags, explicitly modeling the dynamics of the factor. In the static form, the factor appear without any lags, implying that a factor only have a contemporaneous effect on the individual variables, determined by the static *factor loadings*. In this paper, we follow Bernanke, Boivin, et al. (2005) and employ an approximate static form of the DFM, and obtain the estimated factors by using the *Principal Component Analysis* (PCA). The PCA estimates the factors by solving a minimization problem using a non-parametric least square method. As a result, we can extract the factor loadings for each variable by running static regressions of the factors on the respective variables, yielding straightforwardness in estimating individual variable responses to monetary policy shocks.

Estimating static factors from an information set consisting of macroeconomic time series might seem restrictive. It can, however, be demonstrated that the contemporaneous effect of the factors on the individual variables, implicitly accounts for the dynamic process of the factors. Following Stock and Watson (2002b), we describe the *dynamic form* DFM, which is analogous Stock and Watson (2016), with the following equation:²⁴

²³See Bai and Ng (2002) for a technical discussion on the degree of correlation that can be accepted.

²⁴In contrast to Stock and Watson (2016), but similar to Stock and Watson (2002b), we omit the second equation which displays the factor dynamics.

$$X_t = \lambda(L)f_t + e_t \quad (5)$$

where X_t is a $N \times 1$ vector of stationary macroeconomic variables observed for $t = 1, \dots, T$. The macroeconomic variables are affected by the small $q \times 1$ vector of dynamic factors, f_t . The dynamics between the factors and the variables are defined by $\lambda(L)$, which is the lag polynomial of dimension $N \times q$.²⁵ The lag polynomial has finite orders p , where the i^{th} row of $\lambda(L)$ is the dynamic effect of the factor on variable X_i . The idiosyncratic error-term, e_t , is defined as an $N \times 1$ vector, allowed to display a small degree of correlation with the factors as well as across equations. As pointed out by Stock and Watson (2016), the assumption that the lag polynomial is of finite order p allows us to rewrite the dynamic form of Equation (5) into the static form DFM that is estimated using PCA:

$$X_t = \Delta F_t + e_t \quad (6)$$

where the r static factors, F_t , is a $r \times 1$ vector that contain the current and the previous values of the dynamic factors from Equation (5). Consequently, when the value of a dynamic factor in period $t - p$ impact the current outcome of the variable X_{it} , we may write the static factor as: $F_t = [f'_t, \dots, f'_{t-p}]'$. Hence the number of static factors are given by $r = (p + 1) \times q$, and the lagging effect of a factor on an individual variable from the dynamic form is now stacked into the $N \times r$ matrix of static factor loadings, Δ . In particular, the factor loadings for variable i is given by $\Delta_i = [\lambda_{i0}, \dots, \lambda_{ip}]$, i.e., a $1 \times r$ vector that summarize the dynamic effect of a factor into a contemporaneous effect on the variable i .

Observing that the static form of the DFM capture lagging effect of factors on the individual variables, we can employ the PCA to obtain estimates of the factors. As presented by Stock and Watson (2016), the estimates solve the least squares problem in which the factor loadings and the unobserved factors are treated as unknown parameters to be estimated:

$$\min_{F_1, \dots, F_t, \Delta} V_r(\Delta, F), \text{ where } V_r(\Delta, F) = \frac{1}{NT} \sum_{t=1}^T (X_t - \Delta F_t)' (X_t - \Delta F_t) \quad (7)$$

where the solution to the minimization problem is subject to normalization, $N^{-1}\Delta'\Delta = I_r$, since the factors are treated as unobserved. As proved by Stock and Watson (2002b), the solution is to set the factor loadings, $\hat{\Delta}$, equal to $N^{\frac{1}{2}}$ times the eigenvectors, \hat{Z} , of the sample variance matrix of X_t , $\hat{\Sigma}_x$, corresponding to its r largest eigenvalues. The

²⁵ $\lambda(L) = \lambda_1 L + \lambda_2 L^2 + \dots + \lambda_p L^p \implies \lambda(L)f_t = \lambda_1 f_t + \lambda_2 f_{t-1} + \dots + \lambda_p f_{t-p}$

estimated factors, \hat{F} , are then given by:

$$\begin{aligned}\hat{F}_t &= N^{-1} \hat{\Delta}' X_t \\ \hat{F}_t &= N^{-1} (N^{\frac{1}{2}} \hat{Z})' X_t\end{aligned}\tag{8}$$

Importantly, and as elucidated in Stock and Watson (2002b), when N is large, and the estimated k number of factors are at least as large as the true number of factors, r , the estimated factors will span the same space as the true factors, F . In order to determine how many true factors that are present in the information set, we follow Stock and Watson (2010) and use a combination of a priori knowledge, visual inspection and the Information Criteria (IC).

The visual inspection is based on a *scree plot*, introduced by Cattell (1966). The scree plot visualizes the level of explained variance by each factor. The scree plot graphs the ordered eigenvalues of the covariance matrix of X_t against the rank of the eigenvalues, yielding an assessable plot of the marginal contribution by each principal component.

To formally decide the true number of factors that are present in our information set, we employ the Information Criteria developed by Bai and Ng (2002). The criteria is set up as a model selection problem, where the true number of factors is determined by minimizing the trade-off between goodness-of-fit and parsimony:

$$IC_p(k) = \ln \left(V_k(\hat{\Delta}_k, \hat{F}_k) \right) + k \cdot g(N, T)\tag{9}$$

The first term on the right hand side of Equation (9) is the goodness-of-fit measure, i.e., the sum of square residuals from a k -factor model estimated by Equation (7). The second term on the right hand side is the penalty factor, which depends on the k number of factors estimated, the N number of series in X_t from Equation (6), and the time dimension T . Notice that the IC in Equation (9) estimates the true number of factors r under the assumption that N and $T \rightarrow \infty$.²⁶ Following Bernanke, Boivin, et al. (2005), we choose to minimize Equation 9 by using the following penalty term:²⁷

$$g_2(N, T) = k \left(\frac{N + T}{NT} \right) \ln(\min\{N, T\})\tag{10}$$

In addition, the result from using the penalty term in Equation (10) is cross-checked against the following alternative equation:

²⁶See Bai and Ng (2002) for a more technical analysis.

²⁷Notice that Bai and Ng (2002) propose various penalty term in their paper. However, both Bernanke, Boivin, et al. (2005) and Stock and Watson (2016) argue for the use of the penalty term in Equation (10).

$$g_1(N, T) = k \left(\frac{N + T}{NT} \right) \ln \left(\frac{NT}{N + T} \right) \quad (11)$$

By minimizing Equation (9) using the aforementioned penalizing terms we can determine the required number of factors, k , that are necessary to ensure that the estimated factors spans the space of the true factors. However, as emphasized by Bernanke, Boivin, et al. (2005), the information criteria do not necessarily address number of factors needed to identify the effects of a monetary policy shock. Therefore, supplementary to visual inspection and the information criteria, we perform a robustness check of the results by varying the number of factors in the estimated model.

4.3 The Factor-Augmented VAR

When analyzing the transmission mechanism of monetary policy in Norway, we assume that the dynamics of the Norwegian economy is determined by variables directly observed by Norges Bank and a small number of unobserved factors. Following Bernanke, Boivin, et al. (2005), we assume that the joint dynamics between the observable variables and the unobserved factors can be represented by the following transition equation, which is referred to as the Factor-augmented VAR:

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + v_t \quad (12)$$

where $\Phi(L) = \phi_1 + \phi_2 L + \dots + \phi_p L^{p-1}$ is the conformable lag polynomial matrix of finite order, p . Y_t is the $M \times 1$ vector of the observable variables, and F_t is the small $K \times 1$ vector of the unobserved factors. The innovations, v_t , are assumed to be white noise, with the covariance matrix Ω .

First, notice that the FAVAR reduces to the standard VAR depicted in Equation (4) if all coefficients in Φ , that relates Y_t to F_{t-1} , are zero. Second, the FAVAR, as represented by Equation (12), cannot be estimated directly as the factors are unobserved. However, if the unobserved factors, together with Y_t , explain the co-movements in a large set of macroeconomic variables, we can utilize the properties of the DFM to estimate the unobserved factors. Following Bernanke, Boivin, et al. (2005), we denote X_t as the $N \times 1$ vector of macroeconomic variables, referred to as the information set, and assume they are related to the observed variables, Y_t , and the unobserved factors, F_t , as follows:

$$X_t = \Delta^f F_t + \Delta^y Y_t + e_t \quad (13)$$

where Δ^f is a $N \times K$ matrix of factor loadings and Δ^y is a $N \times M$ matrix relating the observed variables to the information set. The error-term, e_t , is a $N \times 1$ vector with expected value of zero, which display a small degree of correlation across equations.²⁸ To estimate Equation (12) and (13), we apply the two-step approach as suggested by Bernanke, Boivin, et al. (2005). The PCA estimation of the information set is performed without including the variables that are assumed to be observed by Norges Bank. As a result, the estimate recovers the common space spanned by the unobserved factors and the observed variables. Therefore, we estimate the first $K + M$ principal components of X_t , denoted $\hat{C}(F_t, Y_t)$. The part of $\hat{C}(F_t, Y_t)$ that is spanned by Y_t is then removed, leaving an estimate of the unobserved factors, \hat{F}_t . In the second step, we replace F_t with \hat{F}_t in Equation (12), and estimate the FAVAR using the standard VAR methodology.

One of the main advantages of the FAVAR approach is that VAR framework extends directly to the FAVAR model. Hence, we can recover the structural monetary policy shock from the *moving average* (MA) representation of the FAVAR:

$$\Phi^*(L) \begin{bmatrix} \hat{F}_t \\ Y_t \end{bmatrix} = \begin{bmatrix} v_{F,t} \\ v_{Y,t} \end{bmatrix} \tag{14}$$

$$\begin{bmatrix} \hat{F}_t \\ Y_t \end{bmatrix} = \Theta(L) \begin{bmatrix} v_{F,t} \\ v_{Y,t} \end{bmatrix}$$

where $\Phi^*(L) = I - \Phi_1(L)(L)$ and $\Theta(L) = [\Phi^*(L)]^{-1}$, and \hat{F} is a vector of the estimated factors. The $\Theta(L)$ is the conformable matrix of coefficients of finite order, p , expressing the current values of the factors and observed variables in terms of current and previous realizations of the innovations only. As emphasized in Section 4.1, estimating the causal effect of the variables in the system require identifying the structural shocks. Following Stock and Watson (2016), we assume that the linearity between the structural shocks, ϵ , and the innovations, v , is given by $v_t = H\epsilon_t$. If H is invertible, we can write the structural shocks as $\epsilon = H^{-1}v_t$ and substitute this expression into Equation (14). Finally, we substitute MA-representation containing the linear combination of the structural shocks into Equation (13), to obtain the estimate of each variables response to a one unit structural monetary policy shock as follows:

²⁸See section 4.2.

$$X_{it} = \begin{bmatrix} \hat{\Delta}^f & \hat{\Delta}^Y \end{bmatrix} \begin{bmatrix} \hat{F} \\ Y_t \end{bmatrix} \tag{15}$$

$$X_{it}^{IRF} = \begin{bmatrix} \hat{\Delta}_i^f & \hat{\Delta}_i^Y \end{bmatrix} \hat{\Theta}(L) H^{-1} v_t$$

Empirical Implementation

In this section, we present the empirical implementation the Factor-augmented VAR framework described in the previous Chapter. First, we describe the data used, before presenting the variable transformations. Finally, we describe the identification of the FAVAR model.

5.1 Data

The dataset consists of a *balanced* panel of monthly macroeconomic time series from 1990:M1 through 2016:M9.^{29,30} The majority of the series are produced by Statistics Norway and downloaded from the Macrobond database.³¹

The data was processed in four stages. First, we corrected for any systematic seasonal variation through ARIMA X-13, implemented by the Eurostat statistical software JDemetera+. This method is similar to what is used by Statistics Norway, and allowed us to account for effects such as moving holidays etc. Naturally, we assume that there is no seasonal pattern in the financial markets, nor import/export prices measured in NOK. Consequently, no seasonal adjustment is performed on variables such variables (exchange rate, interest rates, stock indices, import/export prices).

Second, as the principal component analysis described in Section 4.2 assume a balanced dataset, we performed a temporal disaggregation of the quarterly series, i.e., deriving high frequency data from low frequency data. The statistical literature separates between *pure mathematical methods* and *statistical methods*. For the latter, a high-frequency indicator is used to create new data points to fit the original series, and is the preferred method of temporal disaggregation when an appropriate high-frequency indicator is available (Eurostat, 2015). However, our dataset includes numerous quarterly series, resulting in a too extensive task in obtaining appropriate indicators for each series. As a result, disaggregation of the

²⁹We have used final (i.e. revised) data and not real-time data. Such choice implies that there is a potential discrepancy between the available data for Norges Bank at the time when the Bank decided on the stance of the monetary policy, and the figures we have used.

³⁰Alternatively, we could have collected an *unbalanced* panel of time series. However, such choice complicates our model as it imposes another approach for estimating the factors from an unbalanced dataset. For approaches on mixed frequency data we refer to the methodology outlined in Stock and Watson (2002a), where the factors are estimated using the EM algorithm. Sadly, this choice yields one important consequence, namely that we have to drop all variables where observation starts after M1:1990. Hence, important variables such as the CPI-ATE, PPI and several housing price measures were excluded from our dataset.

³¹The remaining series were collected from the Norges Banks monetary policy reports, the OECD database, and the EIA.

quarterly series is done using a mathematical method. Specifically, we employ the *Denton-adjustment method*, which is referred to as 'acceptable' by the European Statistical System (Eurostat, 2015). The adjustment method, originally proposed by Denton (1971), aim to make the new monthly observations consistent with the quarterly totals, while maximizing the preserved month-to-month changes (Bikker et al., 2010).³²

Third, following Section 4.2, the principal components estimation assumes that all variables in the information set are stationary. Therefore, each series was pre-processed to remove trends and unit roots by taking the first difference of the level/logarithmic-series. In order to determine whether a series is stationary or not, we rely on the Augmented Dicky-Fuller (ADF). To ensure valid test-statistics obtained from ADF, we rely on the Akaike information criterion (AIC) to determine the number of lagged differences. The complete list of variables and their respective transformation process can be found in Appendix A.

The complete data panel includes a total of 103 variables divided into seven categories, namely; "economic activity", "prices", "money and credit", "asset prices", "interest rates", "exchange rates", and "expectations". In general, we have used the same transformation within each group. Specifically, for price indices, economic activity measures, and asset prices we take the first-difference of the log-transformed series. This yields measures such as monthly inflation, month-to-month growth rates, percentage changes in employment/unemployment, and monthly returns. For the interest rates we use the first difference of levels, providing month-to-month percentage point changes. From a theoretical point of view it is possible to argue that comparable interest rates are cointegrated, and therefore should be kept in levels in order to preserve potentially important information in spreads. We are, however, not able to reject the null hypothesis of no cointegration. Hence, we follow Stock and Watson (2005) and take first-difference of all interest rate in the information set.³³

Finally, before estimating the factors we standardize the data. Unit of measurement and variances differs greatly across variables, and we therefore transform the data to have zero mean and unit variance. Such process ensures that the estimated factor loadings are unaffected by both degree of variance and unit of measurement.

The variables in the information set are largely based on Bernanke, Boivin, et al. (2005) and Stock and Watson (2005), with a few intentional exceptions. Similar to Christiano et al. (1998), we refer to all changes in the key policy rate that is not due to new information

³²The method is also implemented by the use of JDemetera+.

³³Stock and Watson (2005) includes various spreads for the US economy to capture this information. We also constructed spreads for our information set an early stage, but found that leaving the interest rates in levels lead to a troublesome autocorrelation in our model.

or changes in a hypothetical loss function as monetary policy shocks. An immediate consequence is that the variables included in our information set should be close to the actual determinants of the Norwegian economy. Assuming that Norges Bank enjoy the complete picture needed to identify the actual determinants of the Norwegian economy, we include several variables that are analyzed by Norges Bank in their monetary policy reports. These include, among other variables, a measure of bank loan losses, debt service ratio, housing price gaps, and credit gaps.³⁴

5.2 Model Specification

To avoid biased results, Norges Bank's choice of monetary policy conduction is reflected by separating the model between the pre- and post-inflation targeting period, i.e., before and after 1999:M6, when the inflation-targeting framework were (informally) implemented in Norway (Gjedrem, 2010). Hence, we deliberately separate the sample into two subsamples, following the same strategy as Boivin and Giannoni (2006) and Boivin, Kiley, et al. (2010), who respectively estimated a VAR and a FAVAR over two samples corresponding to the pre- and post-Volcker periods (pre- and post-1979:Q4). This strategy allows us to examine and compare the two time-periods in order to examine whether the transmission of monetary policy has changed between the pre- and post-inflation targeting periods.

Arguably, the exact choice of break date seems rather arbitrary. However, to test the stability in the factor models, and thereby determine the appropriate break date, Breitung and Eickmeier (2011) propose Chow type tests for structural breaks. However, due to our relatively small sample span, and the noisiness in the data of the pre-1999 period, the tests fails to give conclusive results, where all of the results from our sample indicate several significant structural breaks in the period between 1995 and the new millennium.³⁵ As a consequence we decided to follow the two aforementioned papers, that experienced similar challenges with formal tests. Hence, the sample is separated between the pre- and post-inflation targeting regimes based on the informal implementation of the inflation-targeting framework in 1999. In particular, we assume that the factors driving the dynamics of the economy do not change over time. However, based on such split sample estimation strategy, with a single break point, we cannot exclude the possibility of a more complex evolution in the monetary transmission mechanism.

³⁴For these variables, we take the first difference of the level for any variable that represent a ratio, while no transformations are imposed on the variables that are measured as percentage deviations from a long-term trend.

³⁵For a graphical illustration of the data noisiness we refer to Figure B.1 in the Appendix, describing the recovered structural shocks of the complete sample.

5.2.1 Identification of Factors

In order to determine the appropriate number of factors, we first visually inspect the scree plot, as displayed in Figure C.1 in Appendix C. We note that there is a visual break after the first and sixth component, aligning with a priori knowledge that the estimated number of factors lies somewhere between three and seven. The first component explains 11 percent of the total variance in the data. The marginal contribution from the first component does, however, substantially exceed the subsequent components, where including six components only explains 35 percent of the variation in the data.

We consider the possibility that it is more than six true factors in the information set when we employ the Bai and Ng's IC as elucidated in Section 4.2. The IC is first implemented by using the penalty term in Equation (10), while we cross-check the results by employing the penalty term from Equation (11). Results from the tests are displayed in Appendix C. Both results suggest that the true number of static factors is four, explaining 28 percent of the variation in the included dataset.³⁶

Furthermore, for both the pre- and post-inflation targeting regime, the baseline FAVAR includes four factors, F_t , and treats only the key policy rate, R_t , as the observed variable by Norges Bank. Similar to Bernanke, Boivin, et al. (2005), we do not exploit that R_t is observed. Hence, to identify F_t , we first estimate the common space spanned by both F_t and R_t by extracting the first $4 + 1$ principal components. To remove the principal components dependency on R_t we follow Bernanke, Boivin, et al. (2005), and define variables in the information set as either slow-moving or fast-moving. The slow-moving variables are assumed not to respond contemporaneously to unexpected changes in R_t , such that we obtain an estimate of all common components other than R_t by extracting principal components from the subset of slow-moving variables. We then run a static regression of the common space spanned by both F_t and R_t on the common components from the subset of slow-moving variables, $\hat{C}^s(F_t)$, and the observed variable R_t :

$$\hat{C}(F_t, R_t) = \beta_1 \hat{C}^s(F_t) + \beta_2 R_t + e_t \quad (16)$$

where $\hat{C}(F_t, R_t)$ is the estimate of the common space spanned by both R_t and F_t . By utilizing the estimate of the dependency on R_t we can subtract the effect of R_t from the

³⁶However, as emphasized by Bernanke, Boivin, et al. (2005), the IC does not necessarily indicate the number of factors to include in the FAVAR model to properly describe the Norwegian economy. Hence, the four factors employed in our baseline FAVAR model should only be viewed as the starting point for our analysis.

common space, resulting in the following final step for identifying the factors:

$$\hat{F}_t = \hat{C}(F_t, Y_t) - \hat{\beta}R_t \quad (17)$$

Finally, the estimated factors are included in the standard VAR framework to estimate the Factor-augmented VAR as represented by Equation (12).

5.2.2 Identification of the Factor-augmented VAR

As emphasized in Section 2.3, not merely the current value of the key policy rate, but rather the entire expected path of the key policy rate affect the economy. Consequently, identifying the effect of a change in the key policy rate imply identifying the unexpected changes undertaken by Norges Bank, referred to as the structural monetary policy shocks. The process of identifying these shocks is done in two steps. The first step entails imposing necessary short-run restrictions on the structural linkage in the economy for variables included in the model, while the second step entail determining the appropriate number of lags to capture the dynamics of the Norwegian economy.

In the first step, we employ the recursive identification scheme as proposed by Bernanke, Boivin, et al. (2005). By using this identification scheme, we can recover the structural shocks by imposing restrictions on their contemporaneous effect on the variables included in the model. Notably, the recursive identification requires that H from Equation (15) is a lower triangular matrix. The immediate implication is that the variable ordered last will respond within the same period (a month) to all shocks in the system, while the other variables only respond with a lag to shocks stemming from the variable that is ordered last. The variable ordered next-to-last will respond within a period to variables ordered above, and only with a lag to the variable ordered last. With these short-run restrictions in place, we order all four factors above the key policy rate, similar to Bernanke, Boivin, et al. (2005). By ordering the key policy rate last, the restrictions on the structural shocks imply that the model is estimated under two specific assumptions. The first assumption relates to the conduct of monetary policy, as the ordering imply that Norges Bank can respond within a month to a shock in any of the factors that drive the dynamics of the economy. The second assumption complies with the notion that monetary policy works with a lag, as a shock in the key policy rate will have no effect on the on the factors within a month.³⁷ Once these restrictions are in place, we can identify the structural monetary

³⁷We also considered a model where the exchange rate and the oil price where treated as directly observed to Norges Bank. With this alternative specification, the key policy rate where ordered below the oil price and above the exchange rate, implying that Norges Bank responds contemporaneously to oil price shocks, but only with a lag to exchange rate shocks.

policy shocks as the one-step ahead forecast error in the key policy rate, i.e., the estimated unexpected changes in key policy rate given the value of the factors.

Finally, to ensure that we capture potential lagging effects in the economy, we determine the appropriate lag length. In doing so, we rely on the Likelihood ratio (LR), Jarque-Bera (J-B) and the Lagrange Multiplier test (LM). By performing a pre-estimation test, we find that LR test suggests 13 lags for both periods. Post-estimation analysis, using various number of lags does, however, indicate that a more parsimonious model can be estimated. Using nine lags, we are not able to reject the null of normally distributed innovations as tested by JB. LM test-statistics also show that we cannot reject that there is no autocorrelation in the innovations. Test-statistics for both periods are depicted Appendix C. Including nine lags to estimate a model for the earliest subsample leave us with a total 91 observation, with a sample span ranging from 1991:M11 to 1999:M5. For the inflation-targeting regime, the sample ranges from 1999:M6 to 2016:M9, leaving 207 observations to estimate the parameters.

When the FAVAR is properly identified, we can trace out the response of a monetary policy shock for each variable and interpret the effects causally. First, we estimate the FAVAR and utilize the MA-representation, depicted in Equation (14), and invoke a one-unit change in the one-step ahead forecast error for the key policy rate. Second, we estimate the corresponding response of the factors. Third, we recover the respective factor loadings for each variable. This is done by running a static regression of variable i on the estimated factors and the key policy rate. Finally, we compute the effect of a monetary policy shocks according to Equation (15). When H is invertible, we can define $\Theta(L)H^{-1} = \delta$, and estimate the response to a structural monetary policy shock for variable i as identified by the baseline FAVAR as follows:

$$X_i^{IRF} = \Delta_i^{F_1} \cdot \delta_{F_1}(L) + \Delta_i^{F_2} \cdot \delta_{F_2}(L) + \Delta_i^{F_3} \cdot \delta_{F_3}(L) + \Delta_i^{F_4} \cdot \delta_{F_4}(L) + \Delta_i^R \cdot \delta_R(L) \quad (18)$$

As emphasized by Bernanke, Boivin, et al. (2005), this two-step approach implies the presence of generated regressors. Recall that the factors are identified by running the regression in Equation (16), which increases the uncertainty in the constructed impulse responses. To deal with the additional uncertainty, we estimate the standard error using a parametric bootstrap with 500 draws when estimating the coefficients. We can then construct the bootstrapped confidence intervals, which account for the presence of generated regressors.

Results

In this section we present the empirical findings from the baseline four-factor FAVAR model, with the key policy rate treated as an observed variable. As mentioned previously this thesis pursues two objectives. First, we aim to assess the transmission mechanism of monetary policy in the Norwegian economy. Second, we seek to identify potential changes in the monetary transmission mechanism between the pre- and post-inflation targeting period. Overall, the signs of the estimated impulse responses suggest economically plausible results agreeing with well-established macroeconomic theories.

The impulse responses from the baseline FAVAR are presented in Figure 6.2, displaying the *orthogonalized cumulative response* to a one standard deviation contractionary monetary policy shock. The *red solid line* indicates the response of the *post-inflation targeting period* (1999:M6 to 2016:M9), while the *black broken line* indicates the *pre-inflation targeting period* (1990:M1 to 1999:M5).³⁸ The units of the responses are given in standard deviations, with the shaded areas indicating the bootstrapped one standard-error bands around the point estimates for the post-inflation targeting period.³⁹

6.1 Impulse Responses

Building on Subsection 2.3.1, the *interest rate channel* is by many viewed as the main channel for the monetary policy transmission mechanism. According to theory, an unexpected monetary policy contraction causes short-term interest rates to increase, which in turn should slow-down economic activity and eventually decrease the price pressure. Although not all individual responses are statistically significant, the majority of the point estimates indicates a gradual slow-down in real activity growth.

In particular, the 3M Treasury Bills displays a marginal, but statistically significant contemporaneous increase following the contractionary monetary policy shock. Second, growth

³⁸A one standard deviation contractionary monetary policy shock is equivalent to approximately 17 and 9 basis points unexpected increase in the key policy rate for the pre- and post-inflation targeting period, respectively.

³⁹Similar to Bernanke, Boivin, et al. (2005), the units of responses are kept in standard deviations since we are interested in the nature of relationships between the variables (and not in the coefficient estimates per se). The impulse response functions are interpreted as "a one standard deviation shock in the key policy rate causes a statistical (in)significant increase/decrease in Y for M periods (determined by the length of the period for which the standard-error bands are above or below zero). Such interpretation fits well into objectives like: A) What is the key policy rate impact on Y ? B) When is the maximum impact of the key policy rate on X experienced? C) For how long is there a significant effect of the key policy shock?"

in industrial production declines, and continues to do so before reaching the peak after 6 to 8 months. However, the peak response is in terms of magnitude rather limited, where the peak response indicates only a 0.05 SD decrease from the mean growth rate following the contractionary key policy rate shock. In line with the notion of long-run monetary neutrality for the real economy, the effect of the key policy rate diminishes after a while, evident from the shock turning statistically insignificant after approximately 18 months. Results further suggest a decline in percentage changes of the capacity utilization rate, slower growth in total import, dwellings started, and new constructions. By and large, these findings are consistent with the economic growth slowing down in response to contractionary monetary policy, and widely comparable to the FAVAR-based results presented in Bernanke, Boivin, et al. (2005) and Stock and Watson (2005) for the U.S. economy. Although not statistically significant, point estimates for employment and unemployment are economically intuitive; both respond with a lag, signaling declining growth in employment and an increased unemployment rate.

Results further suggest a statistically significant decline in total consumption by households as a response to the unexpected hike in the interest rate. This result may be due to a negative wealth effect. As emphasized by Modigliani (1966), a higher interest rate should decrease the present value of lifetime assets, and consequently decrease the wealth of consumers holding those assets. As consumption is a function of expected wealth over the lifetime, the result of a contractionary monetary shock should indicate a negative wealth effect, causing a contraction of consumption. And, as seen from the consumption impulse response in Figure 6.2, the sign of the estimate is in line with theory, indicating declining consumption. The effect of the interest rate works with a lag, with the full impact of monetary policy on consumption growth materializing within the first 6 to 18 months. The lagging effect of the key policy rate on consumption is similar to the results found by Boivin, Kiley, et al. (2010), although the timing of the full impact differs. The estimated response to the benchmark index at Oslo Stock Exchange (OSEBX) suggest a marginal, yet significant decrease in returns within the same period as the monetary policy shock occurs. The decrease in return keeps declining over the horizon, but the effect is only statistically significant within the first month.

Furthermore, our results indicate that the *credit channel* could be an important channel in the Norwegian monetary transmission mechanisms. Accordingly, a contractionary monetary policy affects the economic activity through a decline in credit supply from banks and other intermediaries. In line with such theory, our results indicate a decline in the growth of credit for households, where the contractionary effect becomes significant after about 6 months, and remains so within the next year. The decline in the credit growth should to a

large degree be followed by a decline in the monetary aggregates (M2).⁴⁰ However, the estimated response suggests a contemporaneous increase in the money growth, before aligning with economic theory after a year (i.e., turns negative). In response to a tight monetary policy, there is a significant contemporaneous increase in bank loan losses. As expected, this effect is rather persistent, where the increased losses remain statistically significant for about a year. Analyzing the spillover-effect of loan losses to commercial property prices, we observe as expected a prolonged, although insignificant, negative effect.

As regards the impact of the policy upon the exchange rate, it is expected that higher interest rates appreciates the domestic currency. However, as visible by the I-44, the exchange rate remains unresponsive throughout the horizon, where we observe only a small and insignificant initial effect of the monetary policy shock.⁴¹ A similar result are indicated by the confidence indicator.

Finally, consistent with common theory, we should expect that an increasing interest rate should cause lower inflation. However, we find a small and insignificant increase in inflation over the first six months, implying that we are not able to remove the price puzzle despite utilizing a rich information set.⁴² On the other hand, Barth and Ramey (2002) argues for the supply-side effects and present evidence for the so-called *cost channel*. In particular, since firms depend on credit to finance production, their costs rise when the monetary policy is tightened, implying the need to raise prices. In this view the price puzzle does not stem from the commonly argued methodological problem, but instead represents a genuine response to monetary tightening when the cost channel dominates the demand channel.⁴³

6.1.1 Changes in the Monetary Transmission Mechanism

Regarding changes in the monetary policy transmission, our FAVAR analysis yielded inconclusive results, where the most overall notable difference is the somewhat more drawn-out trajectory following the inflation-targeting regime. Hence, the IRFs indicate that the effects of a contractionary policy shock in the most recent period influences the Norwegian economy in a prolonged and less erratic behavior compared to the earliest subsample.

⁴⁰See Lerbak (2013) for a discussion regarding monetary aggregates and credit.

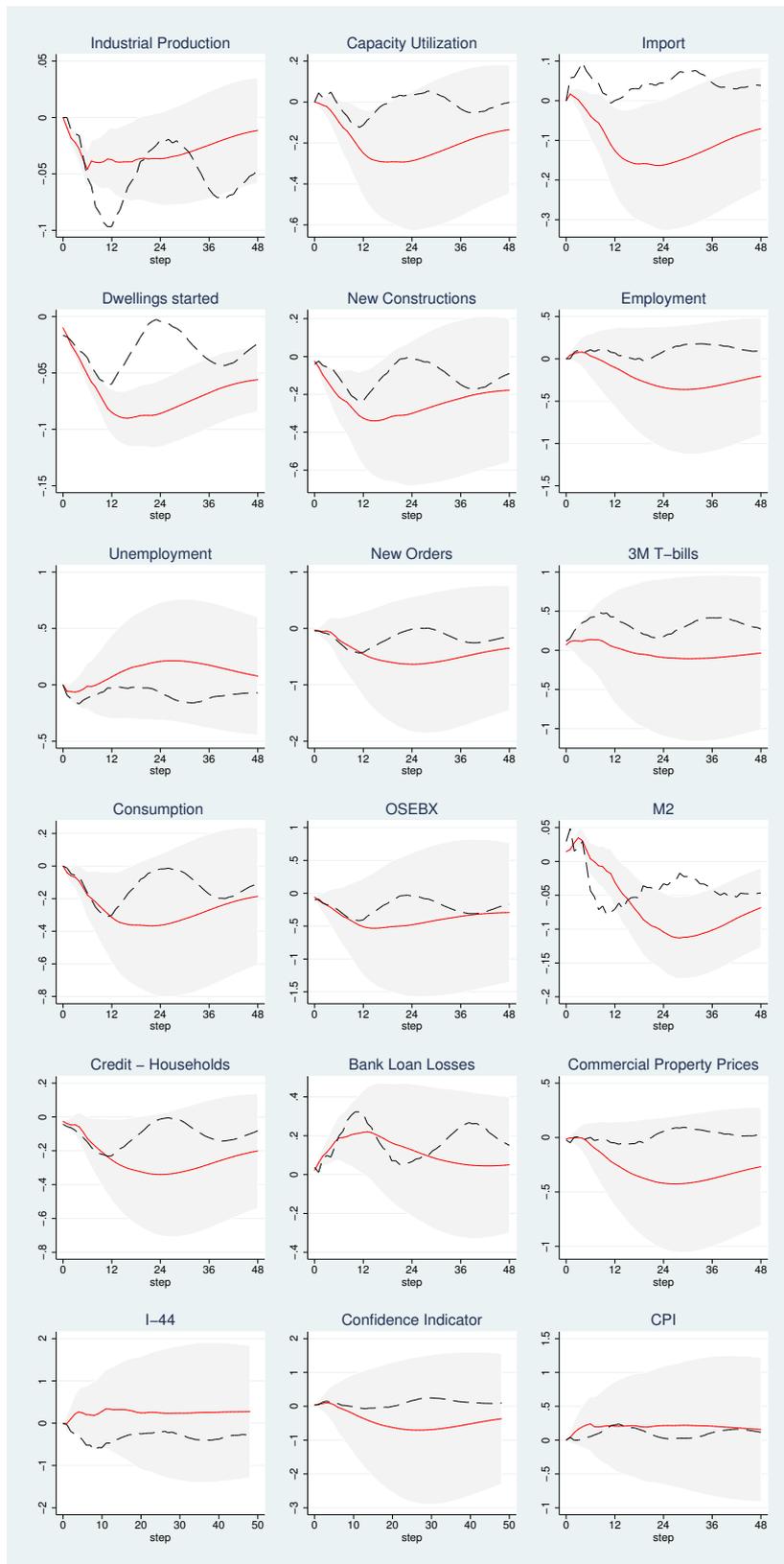
⁴¹I-44 is the nominal effective exchange rate index based on NOK exchange rates as measured against the currencies of Norway's most important trading partners. A rising index indicates a depreciating krone.

⁴²A meta-analysis by Rusnak et al. (2013) finds that none of their eleven studied papers employing the FAVAR methodology proved successful in significantly solving the price puzzle.

⁴³For the U.S. economy, Christiano et al. (2005) uses a DSGE model incorporating the cost channel and finds a minimal role for it. Similarly, Rabanal (2007) suggests that the demand-side effects of monetary policy dominates the supply-side effects, implying a limited role of the cost channel. Henzel et al. (2009) come to similar conclusions analyzing the Euro area.

Furthermore, some variables indicate changes in both *the timing* and *the magnitude* of the policy effect. In particular, the yield on the 3M T-bill displays a significantly higher and prolonged effect within the first 8 to 12 months in the pre-inflation targeting sample. This development suggests that the monetary policy shock had a strengthened direct effect on the short-term interest rate in the pre-inflation targeting period compared to the most recent policy regime.

The second effect we clearly observe is the change of response in the exchange rate (I-44). Compared to the inflation-targeting period, where we observe a non-existing effect throughout the trajectory, the earlier period yields a significant appreciation of the NOK against the key trading partners. With the exception of the initial response, this effect is analogous to the exchange rate effect found in Bjørnland (2009). Further, consistent with the appreciated exchange rate in the earliest period, industrial production falls gradually throughout the first twelve months, whereas the growth in import increases.



Note: The Figure display the orthogonalized cumulative responses to a one standard deviation contractionary monetary policy shock. The red solid line indicates the response of the post-inflation targeting period (1999:M6 to 2016:M9). The black broken line indicates the pre-inflation targeting period (1990:M1 to 1999:M5). Units of the responses are standard deviations, with the shaded areas indicating the bootstrapped one standard-error bands around the point estimates of the inflation-targeting period

Figure 6.2: Impulse Responses to a Contractionary Monetary Policy Shock for the Baseline FAVAR Model (F=4, Y = R).

6.2 Robustness

In order to triangulate our results from the preferred baseline FAVAR specification we examine the sensitivity of changes in the key assumptions. As the first robustness test, the results were cross-checked by varying the number of factors. As a second step, we assume that Norges Bank directly observes both the exchange rate and the oil price.

6.2.1 Number of Factors

Table D.2 in the Appendix D portrays the higher six coefficients of correlation between each of the considered five factors and the variables included in our dataset. The first estimated factor captures the real side of the Norwegian economy, as it shows a high correlation coefficient with confidence indicators measuring the temperature of the mainland economy, as well as the current stock of orders and new export orders. Further, the second factor mimics the variation of the exchange rate channel, where both the trade-weighted exchange index, the I-44, and the key exchange rate pairs (EURNOK, USDNOK, CHFNOK, and GBPNOK) are closely correlated. The third factor seems to capture some of the financial stability considerations analyzed by Norges Bank, in addition to money market rates.

Motivated by Bernanke, Boivin, et al. (2005), we explore whether three factors are sufficient to describe the Norwegian economy. Figure 6.3 displays the estimated impulse responses for the three-factor alternative FAVAR model. In terms of sign and magnitude, the majority of the responses conforms to the results obtained in our baseline FAVAR. However, in contrast to Bernanke, Boivin, et al. (2005), we find that the fourth factor captures significant price pressure information. Evident from Table D.2 in the Appendix D, the six key variables loaded into the fourth factor are all price pressure indicators. Reducing the number of factors into three factors yields a significantly lower explained variance by the common factors in terms of price pressure. According to Table D.1 in the Appendix D, the share of variance explained in the CPI decreases from 31 to 3 percent when the fourth factor is excluded. Therefore, we argue that the fourth factor is essential for describing the price pressure in the Norwegian economy, and excluding it from the baseline model should result in less economically plausible results.

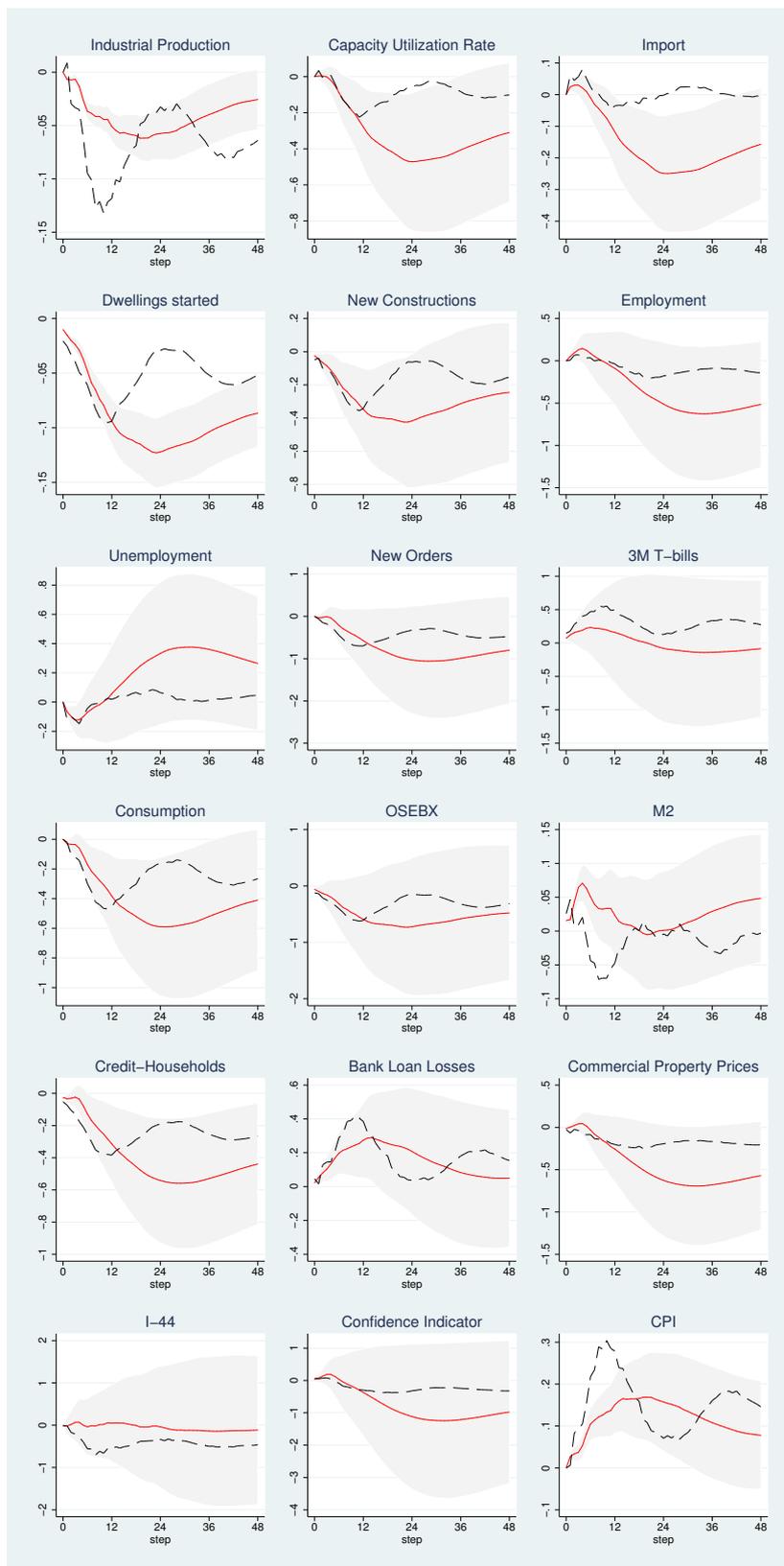
Second, we explore the possibility that five factors are necessary to identify structural monetary policy shocks. Estimated responses from including the fifth factor capturing short- and long-term interest rates are depicted in Figure 6.4. The results are qualitatively similar to the baseline FAVAR. There is, however, some indication of a degrees-of-freedom problem model when the fifth factor is included, evident by the dampened responses and less statistically significant results.

6.2.2 Oil Price and Exchange Rate as Observed Variables

As the Norwegian economy is a small open economy with rich oil reserves, changes in the oil price could affect the economic climate significantly. Consequently, in order to account for potential oil price shocks, we compare the result from our baseline FAVAR to an alternative model where we treat both the exchange rate and the oil price as directly observed by Norges Bank.⁴⁴ The alternative FAVAR is estimated under the assumption that the central bank responds within the same period to both oil price shocks, and shocks in either of the factors. Specifically, the oil price is ordered first, followed by the slow-moving factors, the key policy rate and the exchange rate, respectively.⁴⁵ The results, which are displayed in Figure 6.5, indicates by and large similar results to the baseline FAVAR model.

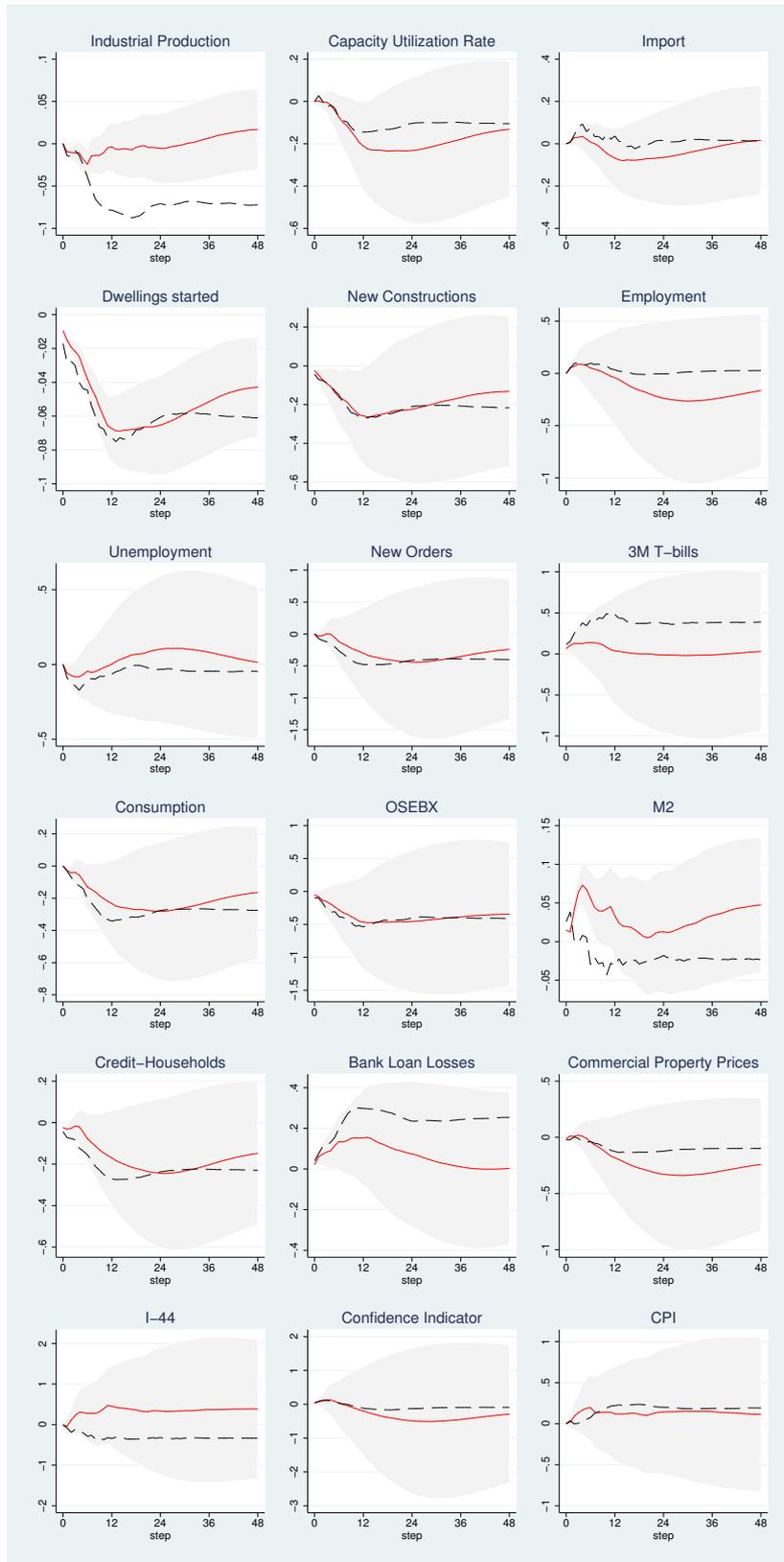
⁴⁴See Aastveit et al. (2016) for an analysis of the oil dependency of the Norwegian economy.

⁴⁵Regarding the recursive identification scheme, we consider it implausible that the exchange rate is not allowed to respond within a period to monetary policy shocks, hence we order the exchange rate last. An implication is that Norges Bank does not respond contemporaneously to currency shocks, which, especially for the pre-inflation targeting regime, might be an unreasonable assumption. Bjørnland (2009) uses a combination of long-run restrictions and sign restrictions to mitigate the problem of the ordering. It is, however, considered to be beyond the scope of this thesis to apply different identification schemes.



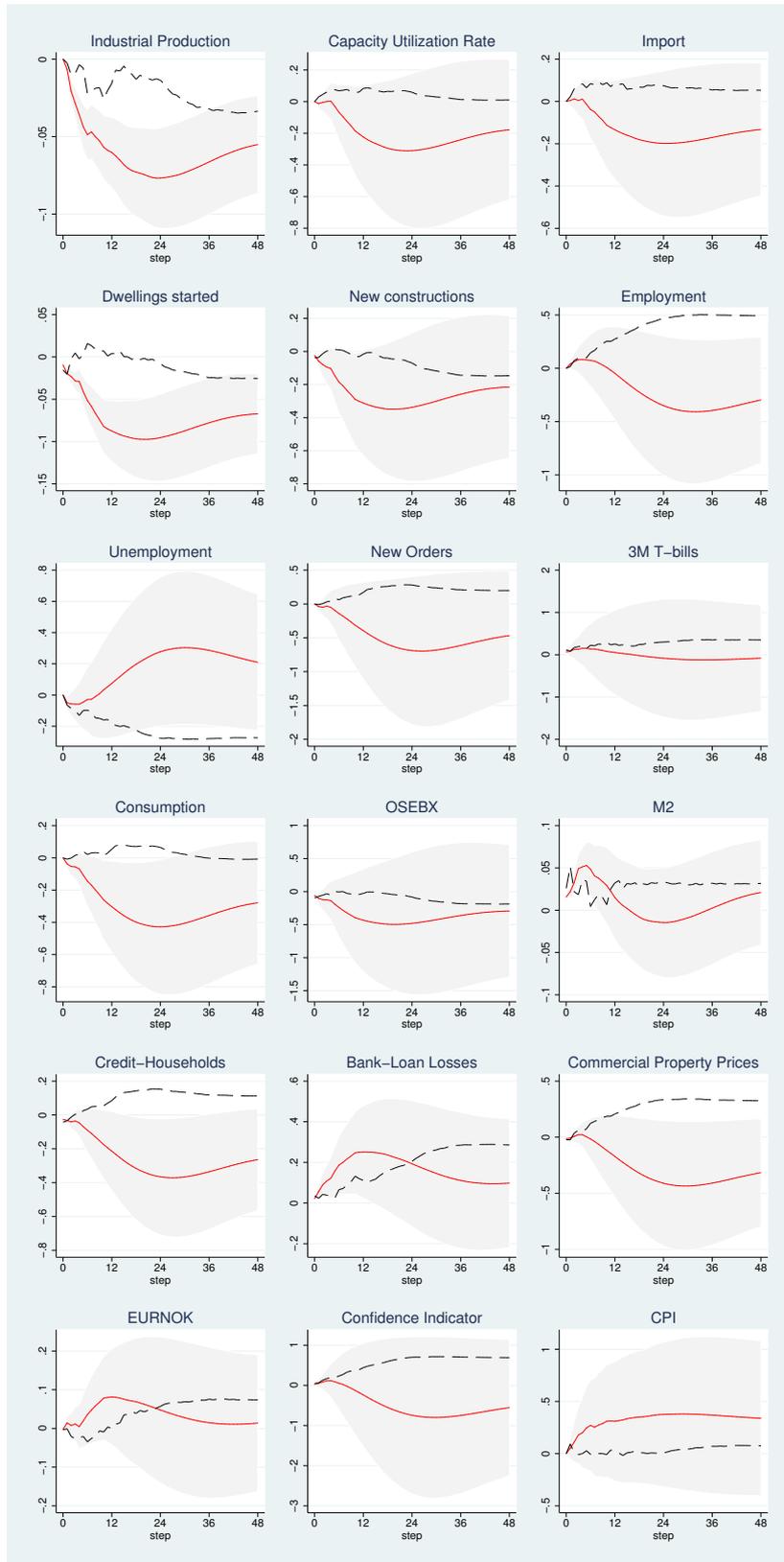
Note: The Figure display the orthogonalized cumulative responses to a one standard deviation contractionary monetary policy shock. The red solid line indicates the response of the post-inflation targeting period (1999:M6 to 2016:M9). The black broken line indicates the pre-inflation targeting period (1990:M1 to 1999:M5). Units of the responses are standard deviations, with the shaded areas indicating the bootstrapped one standard-error bands around the point estimates of the inflation-targeting period

Figure 6.3: Impulse Responses to a Contractionary Monetary Policy Shock for the Alternative FAVAR Model ($F=3$, $Y = R$).



Note: The Figure display the orthogonalized cumulative responses to a one standard deviation contractionary monetary policy shock. The red solid line indicates the response of the post-inflation targeting period (1999:M6 to 2016:M9). The black broken line indicates the pre-inflation targeting period (1990:M1 to 1999:M5).Units of the responses are standard deviations, with the shaded areas indicating the bootstrapped one standard-error bands around the point estimates of the inflation-targeting period

Figure 6.4: Impulse Responses to a Contractionary Monetary Policy Shock for the Alternative FAVAR Model ($F=5$, $Y = R$).



Note: The Figure display the orthogonalized cumulative responses to a one standard deviation contractionary monetary policy shock. The red solid line indicates the response of the post-inflation targeting period (1999:M6 to 2016:M9). The black broken line indicates the pre-inflation targeting period (1990:M1 to 1999:M5).Units of the responses are standard deviations, with the shaded areas indicating the bootstrapped one standard-error bands around the point estimates of the inflation-targeting period

Figure 6.5: Impulse Responses to Contractionary Monetary Policy Shock for the Alternative FAVAR Model (F=4, Y = OIL, R, I=44).

Concluding Remarks and Further Research

Policymakers cannot please everyone when changing the key policy rate as monetary policy affects each channel differently. This heterogeneity is important for the design of monetary policy, as the transmission mechanism of monetary policy can both alter and magnify the initial policy change. Therefore, understanding both the effect and the timing of a policy change is important from both a public perspective and the policymakers' point of view. Following Bernanke, Boivin, et al., this thesis uses the FAVAR methodology to assess the effects of monetary policy in Norway employing a rich dataset of 103 macroeconomic time series ranging from 1991:M1 to 2016:M9. Aiming to identify changes in the effect of monetary policy between the inflation-targeting regime and its policy predecessor, we separate the analysis into two subsamples, namely the pre-inflation targeting period from 1990:M1 to 1999:M5, and the post-inflation targeting period from 1999:M6 to 2016:M9.

7.1 Discussion and Conclusion

This study considers the policy implication of contractionary monetary policy shock on 18 key variables across the Norwegian economy. In general, and across different model specifications, the results proved consistent with accepted macroeconomic theories. In particular, we find that a contractionary monetary policy shock causes a broad decline in economic activity. Further, the results obtained in our analysis points out two interesting findings.

First, the broad dampening effect following a contractionary monetary policy shock emphasizes the role of Norges Bank in supporting the mainland economy, where unexpected policy changes have a direct effect on the economic climate. This implies that the current flexible inflation-targeting regime actually affects the economy according to its idea, where both inflation and output deviations are considered when setting the key policy rate. Hence, we argue that our thesis confirms the theoretical link between the key policy rate and the overall activity of the Norwegian economy.

Second, aiming to address the main channels in which changes in the policy rate transmits into the economy, we observe that the baseline FAVAR in the inflation-targeting policy regime produces moderate, although significant responses through the *interest rate channel* (evident from the 3M T-bills response), implying that the policy change affects other channels to a larger extent. However, neither analyzing the exchange rate channel nor the asset price channel provides conclusive answers, as these responses (e.g. I- 44, OSEBX, Commercial property prices) also produce moderate, and (mostly) insignificant results of

such monetary policy shock. The only channel where we observe partly conclusive answers seems to be the credit channel, where we notice the increased bank loan losses and the slower credit growth in the aftermath of a contractionary policy shock. Thus, analogous to Robstad (2014), we find that monetary policy has prolonged effect on the credit growth of households. Such findings highlight the relative importance of considering the key policy rate's effect on credit when setting the key policy rate.

Despite obtaining economically plausible results where the impulse responses' direction conform with economic theory, we remain careful with extrapolating the results. The argument for approaching the results with carefulness emerges from the partly counterintuitive responses in the exchange rate (I-44) and CPI, in addition to the generally dampened and statistically insignificant impulse responses across the rest of the results. Consequently, one should ask if the identification method employed and the information set included in this thesis is sufficiently able to identify a purely unexpected monetary policy shock.

Aiming to answer such a question, Bernanke, Boivin, et al. (2005) points toward two potential explanations. First, there might be a straightforward explanation if the factors fail to represent the variation in the exchange rate, the CPI, and other theoretical key variables needed to represent the Norwegian economy. However, evident from the tentative interpretation of the estimated factors in Table D.2 of the Appendix D, the four factors employed in the baseline FAVAR model are strongly correlated to both the exchange rate (factor 2) and the price pressure (factor 4). Moreover, one can observe from Table D.1, in the Appendix D, that the four common factors explain 31 percent and 77 percent of the variance in CPI and the exchange rate, respectively. Therefore, we argue that the estimated factors broadly represent the economy as expected, implying that the key issue stems from Bernanke, Boivin, et al.'s second suggested explanation, namely the failure of properly identifying the structural shocks to the economy.

In particular, we suspect that the model fails to identify the unexpected changes in the key policy rate for several reasons. First, the chosen methodological approach in this thesis implies the usage of a *balanced* information set, causing expected key variables in describing the Norwegian economy to be omitted (housing prices, CPI-ATE, PPI, etc.).⁴⁶ If these omitted variables contain new and important information about the current and future stance of the Norwegian economy, that is considered and responded upon by Norges Bank, then our specified model will interpret such response by the Bank as an unexpected policy shock. Hence, the interpreted key policy rate shock in our model might in reality be Norges Bank adjusting to new information. The end result is that what our model interpret as a key policy shock, instead is an *expected* change in the key policy rate, yielding biased

⁴⁶Due to the series starting post 1990:M1.

impulse responses in our FAVAR model.

Second, as the global economy becomes more integrated, foreign developments and their impact on the domestic economy are becoming increasingly important for policymakers. The macroeconomic outlook for small open economies like Norway can be strongly influenced by international developments. However, in our included information set there are limited variables that directly accounts for the Norwegian economy's dependency on foreign developments. Hence, controlling for more variables explicitly monitored by Norges Bank is likely to improve the analysis.

Third, as emphasized by Croushore and Evans (2006), the role of data revision and timing in identifying monetary policy shocks is important. In our information set we have utilized revised data, implying that there is a potential discrepancy between our analyzed information set and the data analyzed by Norges Bank. Furthermore, a fourth issue is related to Norges Bank communication of the expected path for the key policy rate. If, for example, Norges Bank *unexpectedly* communicate that the key policy rate will be lowered at the next interest rate meeting, the structural shock occurs immediately. However, in the estimated model, the unexpected change in the key policy rate is not visible before the actual change occurs, implying that the key policy change actually is expected. In sum, these suboptimal deviations from the theoretical true representation of the information set utilized by the bank, in addition to the missing representation of the policy communication instrument, suggest a large degree of cautiousness should be employed when interpreting the results from the IRFs.

Finally, it should be emphasized that a key implication of our desired separation of the two time frames is that we fail to capture more complex developments over time. There could be a more complex development in the transmission mechanism of monetary policy that we are not able to capture by the split-sample estimation used in our analysis. Considering all five aforementioned potential weaknesses of our specified FAVAR model, we conclude that we most likely fail to properly identify a unexpected monetary policy shock, implying that the results obtained from the IRFs presented in Figure 6.2 are insufficient in representing the *complete* transmission mechanism of monetary policy in Norway.

7.2 Further Research

With regard to the aforementioned strengths and limitations, we suggest several improvement and extensions of our FAVAR analysis. First and foremost, moving from a *balanced* to an *unbalanced* information set allows us including the complete series analyzed by Norges Bank when deciding on the key policy rate. Second, allowing for a larger interaction with

the global economy by including a broader set of foreign variables should improve the results. This argument is underpinned by examining policy reports from Norges Bank, where a significant part of their analysis is directed towards our key trading partners. Ultimately, we argue that using the similar unrevised dataset as utilized by the Bank, in addition to properly account for the policy communication instrument, should improve the analysis.

The result after controlling for these suggested improvements are a methodological framework specifically designed to consider a large information set, where the included variables represent the theoretical true information set of the central bank. As a result, the *complete* monetary policy transmission mechanism could be analyzed, yielding in a correct representation of both the *timing* and the *magnitude* of key variables after a monetary policy shock. Further, such analysis could easily be extended into examining the policy level effects, say to a 25 basis points change in the key policy rate, where the level effects per se are examined. Alternatively, one could use the same methodological framework to examine other shocks to the Norwegian economy. For example, knowing that Norway is a oil dependent economy that is closely integrated to foreign developments, examining the effect of a oil price related shock or a shock occurring in other economies should provide valuable insight to all agents of the Norwegian economy.

Ultimately, fitting the dataset improvements discussed into the time-varying FAVAR (TV-FAVAR) framework, where the factor loadings, factor dynamics, and the variance-covariance matrix of innovations are allowed to vary over time, could to a larger extent capture a more complex development in the monetary policy transmission mechanism. Hence, utilizing such framework could allow for a deeper insight of the changes in the monetary policy transmission mechanism throughout the last decades. Comparing such time-varying FAVAR analysis with structural models such as the New-Keynesian DSGE model, which allows for structural features while emphasizing the role of expectations, should provide valuable insights on both the *effect* and *evolution* of the monetary policy transmission mechanism.⁴⁷

⁴⁷Such suggested methodology follows broadly the paper by Boivin, Kiley, et al. (2010).

References

- Aastveit, Knut Arild, Hilde Bjørnland, and Anders Thorsrud (2016). “The world is not enough! Small open economies and regional dependence”. In: *The Scandinavian Journal of Economics* 118.1.
- Abbate, Angela et al. (2016). “The Changing International Transmission of Financial Shocks: Evidence from a Classical Time-Varying FAVAR”. In: *Journal of Money, Credit and Banking* 48.4, pp. 573–601.
- Angeloni, Ignazio et al. (2003). *Monetary Transmission in the Euro Area: Does the Interest Rate Channel Explain it All?* NBER Working Papers 9984. National Bureau of Economic Research, Inc. URL: <http://EconPapers.repec.org/RePEc:nbr:nberwo:9984>.
- Bagliano, Fabio C. and Claudio Morana (2012). “The Great Recession: US dynamics and spillovers to the world economy”. In: *Journal of Banking and Finance* 36.1, pp. 1–13. URL: <http://dx.doi.org/10.1016/j.jbankfin.2011.06.002>.
- Bai, Jushan and Serena Ng (2002). “Determining the Number of Factors in Approximate Factor Models”. In: 70.1, pp. 191–221.
- (2008). “Large Dimensional Factor Analysis”. In: *Foundations and Trends in Econometrics* 3.2, pp. 89–163. URL: <http://www.nowpublishers.com/article/Details/ECO-002>.
- Ball, Laurence, N. Gregory Mankiw, and Ricardo Reis (2005). “Monetary policy for inattentive economies”. In: *Journal of Monetary Economics* 52.4, pp. 703–725.
- Barth, Marvin J and Valerie Ramey (2002). *The Cost Channel of Monetary Transmission Channel of Monetary Transmission*. Vol. 16.
- Batini, Nicoletta, Richard Harrison, and Stephen P. Millard (2003). “Monetary policy rules for an open economy”. In: *Journal of Economic Dynamics and Control* 27.11-12, pp. 2059–2094.
- Bernanke, Ben and Alan Blinder (1988). “Credit , Money, and Aggregate Demand”. In: *The American Economic Review* 78.2, pp. 435–439.
- Bernanke, Ben, Jean Boivin, and Eliaz Piotr (2005). “Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (Favar) Approach”. In: *The Quarterly Journal of Economics* February, pp. 387–422.
- Bernanke, Ben and Mark Gertler (1989). “Agency Costs, Net Worth, and Business Fluctuations”. In: *The American Economic Review* 79.1, pp. 14–31. URL: <http://www.jstor.org/stable/1804770>.

- Bernanke, Ben, Mark Gertler, and Simon Gilchrist (1999). “Chapter 21 The financial accelerator in a quantitative business cycle framework”. In: *Handbook of Macroeconomics* 1, pp. 1341–1393. URL: <http://www.sciencedirect.com/science/article/pii/S157400489910034X>.
- Bernanke, Ben and Ilian Mihov (1998). “Measuring Monetary Policy”. In: *The Quarterly Journal of Economics* 113.3, pp. 869–902. URL: <http://EconPapers.repec.org/RePEc:oup:qjecon:v:113:y:1998:i:3:p:869-902..>
- Bikker, Reinier, Jacco Daalmans, and Nino Mushkudiani (2010). *A multivariate Denton method for benchmarking large data sets*.
- Bjørnland, Hilde (2008). “Monetary policy and exchange rate interactions in a small open economy”. In: *Scandinavian Journal of Economics* 110.1, pp. 197–221.
- (2009). “Monetary policy and exchange rate overshooting: Dornbusch was right after all”. In: *Journal of International Economics* 79.1, pp. 64–77. URL: <http://dx.doi.org/10.1016/j.jinteco.2009.06.003>.
- Bjørnland, Hilde and Dag Henning Jacobsen (2010). “The role of house prices in the monetary policy transmission mechanism in small open economies”. In: *Journal of Financial Stability* 6.4, pp. 218–229.
- Blanchard, Olivier J. (1985). “Debt, Deficits, and Finite Horizons”. In: *Journal of Political Economy* 93.2, pp. 223–247. URL: <http://www.journals.uchicago.edu/doi/10.1086/261297>.
- Boivin, Jean and Marc Giannoni (2006). *Has Monetary Policy Become More Effective?* CEPR Discussion Papers 5463. C.E.P.R. Discussion Papers. URL: <http://EconPapers.repec.org/RePEc:cpr:ceprdp:5463>.
- Boivin, Jean, Michael T. Kiley, and Frederic S. Mishkin (2010). “How has the monetary transmission mechanism evolved over time?” In: *Handbook of Monetary Economics* 3, pp. 369–422.
- Borio, Claudio and Haibin Zhu (2012). “Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?” In: *Journal of Financial Stability* 8.4, pp. 236–251. URL: <http://dx.doi.org/10.1016/j.jfs.2011.12.003>.
- Breitung, Jörg and Sandra Eickmeier (2011). “Testing for structural breaks in dynamic factor models”. In: *Journal of Econometrics* 163.1, pp. 71–84. URL: <http://dx.doi.org/10.1016/j.jeconom.2010.11.008>.
- Brissimis, Sophocles N. and Nicholas S. Magginas (2006). “Forward-looking information in VAR models and the price puzzle”. In: *Journal of Monetary Economics* 53.6, pp. 1225–1234.

- Bruce, Erik and Tommy Sveen (2017). *Norges Bank Watch 2017 - An independent Evaluation of Monetary Policy in Norway*. URL: http://www.bi.no/Info-avdelingFiles/Forskningskommunikasjon/Norges%20Bank%20Watch%202012%7B%5C_%7DFinal%20Report.pdf.
- Canova, Fabio and Luca Gambetti (2009). “Structural changes in the US economy: Is there a role for monetary policy?” In: *Journal of Economic Dynamics and Control* 33.2, pp. 477–490.
- Cardarelli, Roberto, Selim Elekdag, and Subir Lall (2011). “Financial stress and economic contractions”. In: *Journal of Financial Stability* 7.2, pp. 78–97. URL: <http://dx.doi.org/10.1016/j.jfs.2010.01.005>.
- Case, Karl E, John M Quigley, and Robert J Shiller (2005). “Comparing Wealth Effects: The Stock Market versus the Housing Market Comparing Wealth Effects: The Stock Market versus the Housing Market”. In: *The B.E. Journal of Macroeconomics*. 5.1.
- Cattell, Raymond B. (1966). “The Scree Test For The Number Of Factors”. In: *Multivariate Behavioral Research* 1.2, pp. 245–276. URL: http://dx.doi.org/10.1207/s15327906mbr0102_10.
- Chari, V V, Lawrence J Christiano, and Martin Eichenbaum (1998). “Expectation Traps and Discretion”. In: *Journal of Economic Theory* 81.2, pp. 462–492. URL: <http://www.sciencedirect.com/science/journal/00220531>.
- Christiano, Lawrence, Martin Eichenbaum, and Charles Evans (1998). *Monetary policy shocks: What have we learned and to what end?* URL: <http://linkinghub.elsevier.com/retrieve/pii/S1574004899010058>.
- (2005). “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy”. In: *Journal of political Economy* 113.1, pp. 1–45.
- Ciccarelli, Matteo, Angela Maddaloni, and Jos?? Luis Peydr?? (2015). “Trusting the bankers: A new look at the credit channel of monetary policy”. In: *Review of Economic Dynamics* 18.4, pp. 979–1002. URL: <http://dx.doi.org/10.1016/j.red.2014.11.002>.
- Croushore, Dean and Charles Evans (2006). “Data revisions and the identification of monetary policy shocks”. In: *Journal of Monetary Economics* 53.6, pp. 1135–1160.
- De Nìcolo, Gianni and Marcella Lucchetta (2010). “Systemic Risks and the Macroeconomy”. In: *IMF Working Paper* 10/29. URL: <http://ssrn.com/paper=1555441>.
- Denton, Frank T (1971). *Adjustment of Monthly of Quarterly Series to Annual Totals: An Approach Based on Quadratic Minimizations*.

- Dornbusch, Rüdiger (1976). “Expectations and Exchange Rate Dynamics”. In: *Journal of Political Economy* 84.6, pp. 1161–76. URL: <http://EconPapers.repec.org/RePEc:ucp:jpolec:v:84:y:1976:i:6:p:1161-76>.
- Doz, Catherine, Domenico Giannone, and Lucrezia Reichlin (2011). “A two-step estimator for large approximate dynamic factor models based on Kalman filtering”. In: *Journal of Econometrics* 164.1, pp. 188–205. URL: <http://dx.doi.org/10.1016/j.jeconom.2011.02.012>.
- ECB (2011). *The Monetary Policy of the ECB*, pp. 1–161.
- Eichenbaum, Martin (1992). “Comments on "Interpreting the macroeconomic time series facts: The effects of monetary policy" By Christopher Sims”. In: *European Economic review* 36.5, pp. 1001–1011.
- Eichenbaum, Martin and Charles Evans (1995). “Some empirical Evidence on the Effects of Shocks to Monetary Policy on Exchange Rates”. In: *The Quarterly Journal of Economics* 110.4, pp. 975–1009. URL: <http://www.jstor.org/stable/2946646>.
- Eichengreen, Barry, Donghyun Park, and Kwanho Shin (2012). “When Fast-Growing Economies Slow Down: International Evidence and Implications for China”. In: *Asian Economic Papers* 11.1, pp. 42–87. URL: http://www.mitpressjournals.org/doi/10.1162/ASEP%7B%5C_%7Da%7B%5C_%7D00118.
- Elbourne, Adam (2008). “The UK housing market and the monetary policy transmission mechanism: An SVAR approach”. In: *Journal of Housing Economics* 17.1, pp. 65–87.
- Eurostat (2015). *ESS guidelines on temporal disaggregation: benchmarking and reconciliation*. Tech. rep., pp. 3–38.
- Forni, Mario et al. (2000). “The Generalized Dynamic-Factor Model: Identification And Estimation”. In: *The Review of Economics and Statistics* 82.4, pp. 540–554.
- Galí, Jordi H. (2015). *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications*. Second. New Jersey: Princeton University Press.
- Gerlach, Stefan and Frank Smets (1995). *The Monetary Transmission Mechanism: Evidence from the G-7 Countries*. URL: <http://EconPapers.repec.org/RePEc:cpr:ceprdp:1219>.
- Gertler, Mark and Ben Bernanke (1995). “Inside the black box: The credit channel of monetary policy transmission”. In: *The Journal of Economic Perspectives* 9.4, pp. 27–48.
- Geweke, John (1977). *The Dynamic Factor Analysis of Economic Time Series*. Amsterdam, North-Holland.

- Giordani, Paolo (2004). “An alternative explanation of the price puzzle”. In: *Journal of Monetary Economics* 51.6, pp. 1271–1296.
- Gjedrem, Svein (2005). *Erfaringer med inflasjonsstyring i Norge og andre land*. URL: http://www.norges-bank.no/globalassets/upload/import/publikasjoner/penger_og_kreditt/2005-02/gjedrem.pdf.
- (2010). *Making use of the central bank*. Speech. Oslo. URL: <http://www.norges-bank.no/en/Published/Speeches/2010/Speech-2010-11-17/>.
- Haan, Jakob de, Sander Oosterloo, and Dirk Schoenmaker (2012). *Financial Markets and Institutions - A European Perspective*. Second. Cambridge: Cambridge University Press.
- Hamilton, James D. (1997). “Measuring the Liquidity Effect”. In: *The American Economic Review* 87.1, pp. 80–97. URL: <http://www.jstor.org/stable/2950855>.
- Hammond, Gill (2012). “State of the art of inflation targeting”. In: *CCBS Handbook, Bank of England* 29.29, pp. 1–47. URL: www.bankofengland.co.uk/education/ccbs/handbooks%7B%5C_%7Dlectures.htm.
- Hellum, Erlend and Geir-Are Kårvik (2012). “Hvordan kan vi anslå fremtidige påslag i Nibor?” In: *Aktuell Kommentar* 5.
- Henzel, Steffen et al. (2009). “The price puzzle revisited: Can the cost channel explain a rise in inflation after a monetary policy shock?” In: *Journal of Macroeconomics* 31.2, pp. 268–289. URL: <http://dx.doi.org/10.1016/j.jmacro.2008.10.001>.
- Huber, Florian and Manfred M Fischer (2015). “A Markov switching factor-augmented VAR model for analyzing US business cycles and monetary policy”. Vienna.
- Jordà, Òscar, Moritz Schularick, and Alan M Taylor (2011). “Financial Crises, Credit Booms, and External Imbalances: 140 Years of Lessons”. In: *IMF Economic Review* 59.2, pp. 340–378. URL: <http://dx.doi.org/10.1057/imfer.2011.8>.
- Kim, Soyoung and Nouriel Roubini (2000). “Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach”. In: *Journal of Monetary Economics* 45.3, pp. 561–586. URL: <http://EconPapers.repec.org/RePEc:eee:moneco:v:45:y:2000:i:3:p:561-586>.
- King, Mervyn (2005). *Monetary policy: Practice ahead of theory*. Lecture at Cass Business School. URL: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.172.8840%7B%5C%7Drep=rep1%7B%5C%7Dtype=pdf%7B%5C%7D0Ahttp://papers.ssrn.com/abstract=753989>.

- Kleivset, Christoffer (2011). “Inflasjon og akkomodasjon”. In: *Norges Bank Staff Memo* 21. URL: http://www.norges-bank.no/globalassets/upload/publikasjoner/staff-memo/2011/staffmemo%7B%5C_%7D2111.pdf.
- Kydland, Finn E and Edward C Prescott (1977). “Rules Rather Than Discretion: The Inconsistency of Optimal Plans”. In: *Journal of Political Economy* 85.3, pp. 473–491. URL: <https://ideas.repec.org/a/ucp/jpolec/v85y1977i3p473-91.html>.
- Leeper, Eric, Christopher Sims, and Tao Zha (1996). “What Does Monetary Policy Do?” In: *Brookings Papers on Economic Activity* 27.2, pp. 1–78. URL: <http://EconPapers.repec.org/RePEc:bin:bpeajo:v:27:y:1996:i:1996-2:p:1-78>.
- Lerbak, Marie Norum (2013). “Om pengemengden”. In: *Norges Bank Staff Memo* 14. URL: http://www.norges-bank.no/contentassets/8716a00c7c4f421fbd854400c4b534c2/staff_memo_2013_14.pdf.
- Loayza, N. and K. Schmidt-Hebbel (2002). *Monetary policy functions and transmission mechanisms: an overview*. URL: <http://siteresources.worldbank.org/DEC/Resources/MonetaryPolicyOverview.pdf>.
- Meltzer, Allan H (1995). “Monetary, Credit and (Other) Transmission Processes: A Monetarist Perspective”. In: *Journal of Economic Perspectives* 9.4, pp. 49–72.
- Mishkin, F. S. (2001). *The transmission mechanism and the role of asset prices in monetary policy*. NBER Working Papers. URL: <http://www.nber.org/papers/w8617>
- Modigliani, Franco (1966). “The Life Cycle Hypothesis of Saving, The Demand For Wealth and The Supply of Capital”. In: *Social Research* 33.2, pp. 160–217. URL: <http://www.jstor.org/stable/40969831>.
- Mojon, Benoit and Gert Peersman (2001). “A VAR description of the effects of monetary policy in the individual countries of the Euro Area”.
- Nicolaysen, Jon (2011). *Robust Pengepolitikk i en Urolig Verden*. Oslo.
- Norges Bank (2017a). “Experience with the monetary policy framework in Norway since 2001”.
- (2011). *Monetary Policy Report*. 3/11. Norges Bank.
 - (2016). *Monetary Policy Report with financial stability assessment*. 1/16. Norges Bank.
 - (2017b). *Monetary Policy Report with financial stability assessment*. 1/17. Norges Bank.
 - (2003). *Regulation on monetary policy*. URL: <http://www.norges-bank.no/en/about/Mandate-and-core-responsibilities/Legislation/Regulation-on-Monetary-Policy/>.

- Norges Bank Investment Management (2014). *Norges Bank Investment Management Strategy 2017 -- 2019*. URL: <https://www.nbim.no/en/organisation/strategy-plan/>.
- Olsen, Kjetil, Jan Fredrik Qvigstad, and Øistein Røisland (2002). “Monetary policy in real time : the role of simple rules”. In: *Bank for International Settlements* 19, pp. 368–382.
- Olsen, Øystein (2014). *Financial Imbalances – How Can They be Counteracted?* Speech. URL: <http://www.norges-bank.no/en/Published/Speeches/2014/30-sept-Oystein-Olsen-CME/>.
- Peersman, Gert and Frank Smets (2001). “Are the effects of monetary policy in the euro area greater in recessions than in booms”. In: *European Central Bank Working Paper Series* 52.
- Pétursson, Thórarinn G. (2001). “The transmission mechanism of monetary policy”. In: *Monetary Bulletin A Quarterly Publication of the Central Bank of Iceland* 3.4, pp. 62–77.
- Pisani-ferry, Jean and Maria Ramos (2011). *Rethinking Central Banking*. Tech. rep. Washington DC: Brookings Institution.
- Primiceri, Giorgio E (2005). “Time Varying Structural Vector Autoregressions”. In: *Review of Economic Studies* 72.3, pp. 821–852.
- Rabanal, Paul (2007). “Does inflation increase after a monetary policy tightening? Answers based on an estimated DSGE model”. In: *Journal of Economic Dynamics and Control* 31.3, pp. 906–937.
- Rajan, Raghuram G. (2005). “Has financial development made the world riskier?” In: *Proceedings - Economic Policy Symposium - Jackson Hole* Aug, pp. 313–369. URL: <http://ideas.repec.org/a/fip/fedkpr/y2005iaugp313-369.html>.
- Reinhart, Carmen and Kenneth Rogoff (2014). “Recovery from Financial Crises: Evidence from 100 Episodes.” In: *American Economic Review*, 104.5, pp. 50–55.
- (2009). “The Aftermath of Financial Crises”. In: *The American Economic Review* 99.2, pp. 466–472. URL: <http://www.jstor.org/stable/25592442>.
- Robstad, Ørjan (2014). “House prices, credit and the effect of monetary policy in Norway: Evidence from Structural VAR Models”. In: *Working Paper Series Norges Bank* 5.
- Roger, Scott (2010). “Inflation Targeting”. In: *NBER Working Paper Series* 16654.
- Rudebusch, Glenn D. (1995). “Federal Reserver Interest Rate Targeting, Rational Expectations and The Term Structure”. In: *Journal of Monetary Economics* 35, pp. 245–274.

- Rusnak, Marek, Tomas Havranek, and Roman Horvath (2013). “How to Solve the Price Puzzle? A Meta-Analysis”. In: *Journal of Money, Credit and Banking* 45.1, pp. 37–70.
- Sargent, Thomas and Christopher Sims (1977). *Business cycle modeling without pretending to have too much a priori economic theory*. Working Papers 55. Federal Reserve Bank of Minneapolis. URL: <http://EconPapers.repec.org/RePEc:fip:fedmwp:55>.
- Schjøtt-Pedersen, Karl Erik (2001). “Omleggingen av den økonomiske politikken”. In: *Økonomisk Forum* 5.
- Sims, Christopher (1992). “Interpreting the macroeconomic time series facts. The effects of monetary policy”. In: *European Economic Review* 36.5, pp. 975–1000.
- (1980). “Macroeconomics and Reality”. In: *Econometrica* 48.1, pp. 1–48.
- Sims, Christopher and Tao Zha (2006). “Were There Regime Switches in U . S . Monetary Policy ?” In: *American Economic Association* 96.1, pp. 54–81.
- Smets, Frank (2014). “Financial stability and monetary policy: How closely interlinked?” In: *International Journal of Central Banking* 10.2, pp. 263–300.
- Soares, Rita (2013). “Assessing monetary policy in the euro area: a factor-augmented VAR approach”. In: *Applied Economics* 45.19, pp. 2724–2744. URL: <http://dx.doi.org/10.1080/00036846.2012.676736>.
- Stiglitz, Joseph and Andrew Weiss (1981). “Credit Rationing in Markets with Imperfect Information”. In: *American Economic Review* 71.3, pp. 393–410. URL: <http://EconPapers.repec.org/RePEc:aea:aecrev:v:71:y:1981:i:3:p:393-410>.
- Stock, James and Mark Watson (1998). “Diffusion Indexes”.
- (2010). “Dynamic factor models”. In: *Oxford Handbook of Economic Forecasting* July, pp. 1–43. URL: <http://link.springer.com/article/10.1007/s10182-006-0219-z>.
- (2016). “Factor Models and Structural Vector Autoregressions in Macroeconomics”. In: *Handbook of Macroeconomics Vol. 2*, pp. 1–111.
- (1999). “Forecasting Inflation”. In: *Journal of Monetary Economics* 44.2, pp. 293–335.
- (2002b). “Forecasting Using Principal Components from a Large Number of Predictors”. In: *Journal of the American Statistical Association* 97.460, pp. 1167–1179. URL: <http://www.jstor.org/stable/3085839>.
- (2005). “Implications of Dynamic Factor Models for VAR Analysis”.
- (2002a). “Macroeconomic Using Forecasting Diffusion Indexes”. In: *Journal of Business and Economic Statistics* 20.2, pp. 147–162.

- Stoltz, Per, Gram Gerhard, and Trond Meinich (2015). *Norges Bank*. Store Norske Leksikon. URL: https://snl.no/Norges%7B%5C_%7DBank..
- Svensson, Lars E.O. (2012). “Comment on Michael Woodford, ‘Inflation Targeting and Financial Stability’”. In: *Sveriges Riksbank Economic Review* 1, pp. 33–39.
- (2010). “Inflation targeting after the financial crisis”. In: pp. 1–9.
- (2002). “Inflation targeting: Should it be modeled as an instrument rule or a targeting rule?” In: *European Economic Review* 46.4-5, pp. 771–780. URL: <http://EconPapers.repec.org/RePEc:eee:eecrev:v:46:y:2002:i:4-5:p:771-780>.
- Taylor, John B. (1993). “Discretion versus policy rules in practice”. In: *Carnegie-Rochester Confer. Series on Public Policy* 39.C, pp. 195–214.
- Taylor, John B (2007). “Housing and monetary policy”. In: *Proceedings - Economic Policy Symposium - Jackson Hole*, pp. 463–476. URL: <http://EconPapers.repec.org/RePEc:fip:fedkpr:y:2007:p:463-476>.
- (1995). “The Monetary Transmission Mechanism: An Empirical Framework”. In: *Journal of Economic Perspectives* 9.4, pp. 11–26. URL: <http://www.aeaweb.org/articles?id=10.1257/jep.9.4.11>.
- The International Monetary Fund (2017). “Are Countries Losing Control of Domestic Financial Conditions?” In: *IMF Global Financial Stability Report* April 2017, pp. 83–108.
- Thøgersen, Øystein (2011). “Pengepolitikens Evolusjon”. In: *Krise, Omstilling og vekst* 36/11.
- Tobin, James (1969). “A General Equilibrium Approach to Monetary Theory”. In: *Journal of Money, Credit and Banking* 1.1, pp. 15–29. URL: <http://EconPapers.repec.org/RePEc:mcb:jmoncb:v:1:y:1969:i:1:p:15-29>.
- Triami Media BV (2017). *global-rates.com*. URL: <http://www.global-rates.com> (visited on 04/04/2017).
- Walsh, Carl E. (2009). “Inflation targeting: What have we learned?” In: *International Finance* 12.2, pp. 195–233.
- Woodford, Michael (2005). “Central-Bank Communication and Policy Effectiveness”. In: *Federal Reserve Bank of Kansas City Journal Proceedings*, pp. 399–474.
- (2011). “Inflation Targeting and Financial Stability”. In: *NBER Working Paper Series* 17967.
- (2003). “Inflation targeting and optimal monetary policy”. In: *Federal Reserve Bank of St. Louis Review* 86.4, pp. 15–41.

Appendices

A Data Description and Transformation

The table show the description of the data, whether it is assumed to be slow (S) or fast (F) moving, transformation taken to attain stationarity, and the source of the data.

The transformation codes are: 1 – No transformation (i.e., the variable is stationary in level), 2 – First difference of the level, 3 – Logarithm, and, 4 – First difference of logarithm.

<i>#</i>	<i>Description</i>	<i>Tr.</i>	<i>Fast/Slow</i>	<i>Source</i>
Real Output and Income				
1	Industrial production, Index - Total (2005 =100)	4	S	Statistics Norway
2	Industrial production, Index - Capital goods (2005 =100)	4	S	Statistics Norway
3	Industrial production, Index - Consumer goods (2005 =100)	4	S	Statistics Norway
4	Industrial production, Index - Intermediate goods(2005=100)	4	S	Statistics Norway
5	Industrial production, Index - Non-durable consumer goods (2005 = 100)	4	S	Statistics Norway
6	Industrial production, Index - Durable consumer goods (2005 = 100)	4	S	Statistics Norway
7	Industrial production, Index - Energy (2005) = 100	4	S	Statistics Norway
8	Capacity Utilization - Capital goods	2	S	Statistics Norway
9	Capacity Utilization- Consumer goods	2	S	Statistics Norway
10	Capacity Utilization - Intermediate goods	2	S	Statistics Norway
11	Capacity Utilization - Manufacturing	2	S	Statistics Norway
12	Capacity Utilization - Mining & Quarrying	2	S	Statistics Norway
13	Gross Capital Formation, NOK (base year=2014)	4	S	Statistics Norway
14	Import, total (base year=2014)	4	S	Statistics Norway
15	Export, total (base year=2014)	4	S	Statistics Norway

<i>#</i>	<i>Description</i>	<i>Tr.</i>	<i>Fast/Slow</i>	<i>Source</i>
16	Final Consumption Expenditure Households - Total	4	S	Statistics Norway
17	Final Consumption Expenditure, households - Services	4	S	Statistics Norway
18	Final Consumption Expenditure, Households - Goods	4	S	Statistics Norway
19	Final Consumption Expenditure - Total	4	S	Statistics Norway
20	Dwellings started - Total	4	F	Statistics Norway
Employment and Unemployment				
21	Employment - Number of persons employed (OECD)	4	S	OECD
22	Unemployment - Number of persons unemployed (LFS)	4	S	Statistics Norway
23	Unemployment - Rate, percent of labor force (LFS)	1	S	Statistics Norway
24	Unemployment - Number of persons unemployed (NAV)	4	S	Statistics Norway
Prices				
25	Consumer Price Index, CPI - Total (2015=100)	4	S	Statistics Norway
26	Consumer Price Index - Alcoholic beverages and tobacco (2015=100)	4	S	Statistics Norway
27	Consumer Price Index- Clothing and footwear (2015=100)	4	S	Statistics Norway
28	Consumer Price Index - Communications (2015=100)	4	S	Statistics Norway
29	Consumer Price Index - Food and non-alcoholic beverages (2015=100)	4	S	Statistics Norway
30	Consumer Price Index - Furnishing and household equipment (2015=100)	4	S	Statistics Norway
31	Consumer Price Index - Health (2015=100)	4	S	Statistics Norway
32	Consumer Price Index- Housing, water, electricity, gas & other fuels (2015=100)	4	S	Statistics Norway
33	Consumer Price Index - Misc. goods and services (2015=100)	4	S	Statistics Norway
34	Consumer Price Index - Recreation and culture (2015=100)	4	F	Statistics Norway

<i>#</i>	<i>Description</i>	<i>Tr.</i>	<i>Fast/Slow</i>	<i>Source</i>
35	Consumer Price Index- Restaurants and hotels (2015=100)	4	F	Statistics Norway
36	Consumer Price Index - Transport (2015=100)	4	F	Statistics Norway
37	Consumer Price Index - Petrol (2015=100)	4	F	Statistics Norway
38	Export Prices, Index - Total (2000=100)	4	S	Statistics Norway
39	Export Prices, Index -Excl. Crude oil and natural gas (2000=100)	4	S	Statistics Norway
40	Export Prices, Index - Energy products (2000=100)	4	S	Statistics Norway
41	Export Prices, Index - Non-durable (2000=100)	4	S	Statistics Norway
42	Export Prices, Index - Durable (2000=100)	4	S	Statistics Norway
43	Export Prices, Index - Energy products, crude oil and remaining mineral fuels (2000=100)	4	S	Statistics Norway
44	Import Prices, Index - Total (2000=100)	4	S	Statistics Norway
45	Import Prices, Index - Energy products (2000=100)	4	S	Statistics Norway
46	Import Prices, Index - Non-durable consumer goods (2000=100)	4	S	Statistics Norway
47	Import Prices, Index - Durable consumer goods (2000=100)	4	S	Statistics Norway
48	Import Prices, Index - Energy products, crude oil and remaining mineral fuels (2000=100)	4	S	Statistics Norway
49	Import Prices, Index - Passenger cars	4	S	Statistics Norway
50	Wholesale Price Index - Totals (2005=100)	4	S	Statistics Norway
51	First-hand Domestic Sales - Whole economy (2000=100)	4	S	Statistics Norway
52	First-hand Domestic Sales - Domestic (2000=100)	4	S	Statistics Norway
53	First-hand Domestic Sales - Food (2000=100)	4	S	Statistics Norway

<i>#</i>	<i>Description</i>	<i>Tr.</i>	<i>Fast/Slow</i>	<i>Source</i>
54	First-hand Domestic Sales - Manufactured goods (2000=100)	4	S	Statistics Norway
55	First-hand Domestic Sales - Machinery and transport (2000=100)	4	S	Statistics Norway
56	First-hand Domestic Sales - Crude materials (2000=100)	4	S	Statistics Norway
57	Crude Oil, Brent	4	F	EIA
58	Real Commercial Property Prices	4	F	Norges Bank
Exchange Rates				
59	NOK-Index, I44	4	F	Norges Bank
60	NOK-Index, TWI	4	F	Norges Bank
61	USDNOK	4	F	Norges Bank
62	GBPNOK	4	F	Norges Bank
63	EURNOK	4	F	Norges Bank
64	SEKNOK	4	F	Norges Bank
65	CHFNOK	4	F	Norges Bank
66	JPYNOK	4	F	Norges Bank
Interest Rates				
67	Key Policy Rate	2	F	Statistics Norway
68	NIBOR, 1 month fixing	2	F	Norges Bank
69	NIBOR, 3 month fixing	2	F	Oslo Stock Exchange
70	NIBOR, 6 month fixing	2	F	Oslo Stock Exchange
71	Treasury Bills, 3 month, yield	2	F	Oslo Stock Exchange
72	Government Bond, 3 years, yield	2	F	Oslo Stock Exchange
73	Government Bond, 5 years, yield	2	F	Oslo Stock Exchange
74	Government Bond, 10 years, yield	2	F	Oslo Stock Exchange
Stock Prices				
75	OSEAX	4	F	Oslo Stock Exchange
76	OSEBX	4	F	Oslo Stock Exchange

<i>#</i>	<i>Description</i>	<i>Tr.</i>	<i>Fast/Slow</i>	<i>Source</i>
Money and Credit Aggregates				
77	Monetary aggregates: M0	4	F	Statistics Norway
78	Monetary aggregates: M2	4	F	Statistics Norway
79	C2 - Mainland	4	F	Statistics Norway
80	C2- Households	4	F	Statistics Norway
81	C2 - Non-financial corporations	4	F	Statistics Norway
Industrial New Orders and Stock of Orders				
82	New orders, Index, manufacturing - Domestic (2005 =100)	4	F	Statistics Norway
83	New orders, Index, manufacturing - Export (2005 = 100)	4	F	Statistics Norway
84	Stock of Orders, manufacturing - Domestic market (2005=100)	4	F	Statistics Norway
85	Stock of Orders, manufacturing - Export market (2005=100)	4	F	Statistics Norway
86	Construction, new orders - all forms of construction (2010=100)	4	F	Statistics Norway
87	Construction, new orders - Non-residential (2010=100)	4	F	Statistics Norway
88	Construction, new orders - Residential (2010=100)	4	F	Statistics Norway
Confidence Indicators				
89	Confidence indicator - Manufacturing	1	F	Statistics Norway
90	Confidence indicator - Intermediate goods	1	F	Statistics Norway
91	Confidence indicator - Consumer goods	1	F	Statistics Norway
92	Confidence indicator - Capital goods	1	F	Statistics Norway
Miscellaneous				
93	Credit to GDP all	2	F	Norges Bank
94	K2/BNP, non-financial corporations	2	F	Norges Bank
95	Credit gap, households	1	F	Norges Bank

<i>#</i>	<i>Description</i>	<i>Tr.</i>	<i>Fast/Slow</i>	<i>Source</i>
96	Credit gap, non-financial corporations	1	F	Norges Bank
97	Housing prices/Disposable income	2	F	Norges Bank
98	Housing Prices, deviations from trend	1	F	Norges Bank
99	Real Commercial Property Prices, deviation from trend	1	F	Norges Bank
100	Banks' wholesale funding ratio	2	F	Norges Bank
101	Bank loan losses as share of gross lending	2	F	Norges Bank
102	Interest burden (Interest payment as share of total income)	2	F	Norges Bank
103	Debt Service Ratio (Debt as share of total income)	2	F	Norges Bank

B Recovered Structural Shocks

Figure B.1 displays the recovered structural shocks from the baseline FAVAR model. The red solid line indicates the pre-inflation targeting period, while the blue solid line indicates the post-inflation targeting regime.

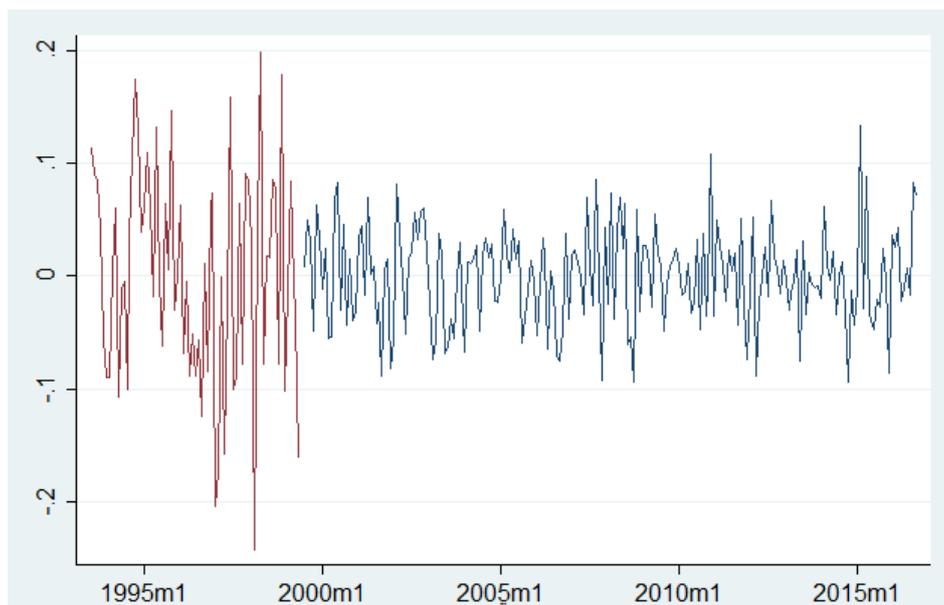


Figure B.1: The Recovered Structural Shocks from the Baseline FAVAR Model.

C Model Selection

To formally determine the true number of factors in the data, we relied on the Scree plot and the IC:

The scree plot graphs the ordered eigenvalues of the covariance matrix of the information set against the rank of the eigenvalues. Each blue bullet represent a principle component and has a corresponding eigenvalues describing the share of variance explained. The first principle component explains about 11 percent of the variation in the data.

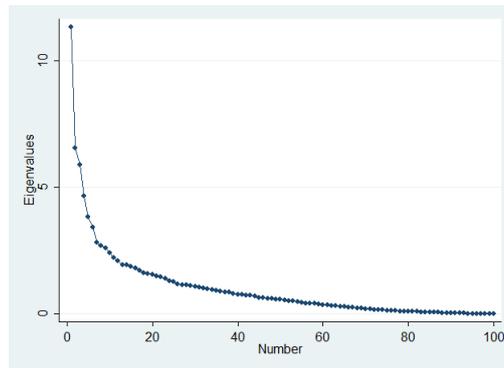


Figure C.1: Scree Plot of Eigenvalues after the Principal Component Analysis.

The results from the Bai and Ng (2002) Information Criteria are displayed in Table C.1. The criteria is set up as a model selection problem, where the true number of factors is determined by minimizing the trade-off between goodness-of-fit and parsimony. The lowest value indicate the best fit.

Table C.1: Results from the Bai and Ng (2002) Information Criteria.

k	$IC_1(k)$	$IC_2(k)$
1	10.290761	10.294494
2	10.272507	10.279973
3	10.256555	10.267755
4*	10.251874*	10.266807*
5	10.254912	10.273578
6	10.261295	10.283694
7	10.274375	10.300508
8	10.287839	10.317705
9	10.300694	10.334294
10	10.315028	10.35236

To determine the number of lags to include, we relied on the Likelihood-Ratio test, the Jarque-Bera test for normality, and the Lagrange-Multiplier test.

The LR-test statistics is based on the likelihood ratio, which expresses how many more times likely the data are under one model than the other. Using the LR test statistics for lag selection, the LR test compares a model with p lags to a model with $p-1$ lags. The null hypothesis is that all the coefficients of all variables in the model on the p^{th} lag are zero, such that a higher likelihood ratio indicate a more likely null hypothesis. While other tests, such as AIC and BIC, penalizes additional lags and might provide parsimonious models, the LR test instead only consider whether or not additional lags have explanatory power.

The JB-test is based on checking whether the data conforms with the properties of the normal distribution. In particular, it tests whether there is skewness and/or kurtosis present in the data, and the general formula is given by:

$$JB = \frac{N - k}{6} \cdot \left(S^2 + \frac{1}{4}(C - 3)^2 \right)$$

where N is the number of observations, k is the number of dependent variables, S^2 is the squared skewness, and C is the estimated kurtosis. The null hypothesis of the test is that data displays neither skewness, nor kurtosis, and STATA present the P-value from this test. Using nine lags, we where not able to reject the that innovations from all equations where normally distributed, as seen in table C.2 and C.3.

Table C.2: Results from the Model Selection Tests for the Post-inflation Targeting Period.

<i>Lag</i>	<i>LR</i>	<i>JB*</i>	<i>LM**</i>
2	73.58	0.00000	0.36212
3	43.081	0.00529	0.54300
6	34.013	0.00053	0.24686
9	29.119	0.13629	0.89061
12	84.985	-	0.89014
15	19.55	-	0.45321

* JB result is the p-value for H_0 equal normality.

** LM results depicts p-value where H_0 for the Baseline FAVAR.

Table C.3: Results from the Model Selection Tests for Pre-inflation Targeting Period.

<i>Lag</i>	<i>LR</i>	<i>JB*</i>	<i>LM**</i>
2	82.253	0.00043	0.27992
3	32.027	0.09737	0.21530
6	34.62	0.0302	0.98850
9	55.783	0.84694	0.53122
12	69.311	-	0.21184
15	216.43	-	0.99303

* JB result is the p-value for H_0 equal normality.

** LM results depicts p-value for H_0 for the Baseline FAVAR.

D Descriptive Data for Factor Analysis

Table D.1 displays the R^2 for regressions of the included series in the result section on the four common factors employed in the baseline FAVAR model. Further, on the next page in the Appendix, Table D.2 displays the higher six coefficients of correlations between each of the six factors considered and the variables included in our dataset.

Table D.1: R^2 for Regressions of Selected Series on Common Factors.

#		Complete	Pre-inflation	Post-inflation
		Sample	Targeting	Targeting
		<i>1990:M1-2016:M9</i>	<i>1990:M1-1999:M5</i>	<i>1999:M6-2016M9</i>
1	Industrial Production	0.018	0.084	0.011
9	Capacity Utilization Rate	0.149	0.197	0.224
58	Import	0.060	0.027	0.093
60	Dwellings Started	0.008	0.022	0.005
61	New Constructions	0.144	0.124	0.259
13	Employment	0.290	0.304	0.426
14	Unemployment	0.153	0.196	0.186
17	New Orders	0.466	0.378	0.515
71	3M T-bills	0.207	0.243	0.287
21	Consumption	0.179	0.160	0.236
89	OSEBX	0.320	0.275	0.383
84	M2	0.027	0.037	0.031
86	Credit-Households	0.118	0.202	0.141
100	Bank Loan Losses	0.131	0.148	0.212
97	Commercial Property Prices	0.231	0.489	0.211
75	I-44	0.771	0.700	0.847
64	Confidence Indicator	0.850	0.742	0.895
25	CPI	0.312	0.121	0.438

Table D.2: Correlation between the Factors and the Dataset.

		Complete	Pre-inflation	Post-inflation	
		Sample	Targeting	Targeting	
<i>#</i>		<i>1990:M1-2016:M9</i>	<i>1990:M1-1999:M5</i>	<i>1999:M6-2016M9</i>	
Factor 1	64	Confidence Indicator - Manufacturing	0.836	0.7881	0.8515
	65	Confidence Indicator - Intermediate Goods	0.777	0.7254	0.8056
	66	Confidence Indicator - Consumer Goods	0.745	0.7006	0.7751
	67	Confidence Indicator - Capital Goods	0.651	0.6006	0.6712
	19	Stock of Orders - Domestic	0.644	0.5697	0.6864
	18	New Orders - Export	0.638	0.3617	0.7061
Factor 2	75	NOK Index - I-44	0.780	0.7236	0.8014
	76	NOK Index TWI	0.771	0.7166	0.7932
	79	EURNOK	0.667	0.587	0.6906
	77	USDNOK	0.602	0.4924	0.6552
	81	CHFNOK	0.600	0.3979	0.6572
	78	GBPNOK	0.596	0.6347	0.595
Factor 3	94	Credit-to-GDP for Non-fin. Corp.	0.607	0.2753	0.6287
	98	Real Commercial Property Prices - Dev. from Trend	0.532	0.4228	0.4371
	70	NIBOR 6M	0.514	0.7275	0.2968
	102	Debt Service Ratio	0.497	0.4983	0.3416
	69	NIBOR 3M	0.494	0.6914	0.3156
	91	Credit-to-GDP	0.463	0.2416	0.4319
Factor 4	51	First-hand Domestic Sales - Whole Economy	0.623	0.3836	0.6939
	52	First-hand Domestic Sales - Domestic	0.566	0.0102	0.6572
	40	Export Prices - Energy Products	0.523	0.5537	0.5053
	25	CPI - Total	0.520	0.2527	0.605
	43	Export Prices - Energy Products and Crude Oil	0.516	0.5542	0.4963
	39	Export Prices - Excl. Crude Oil	0.513	0.3883	0.5314
Factor 5	72	Government Bonds 3Y	0.606	0.8382	0.2712
	69	NIBOR 3M	0.597	0.8001	0.0968
	70	NIBOR 6M	0.590	0.8213	0.1197
	68	NIBOR 1M	0.559	0.7318	0.0576
	73	Government Bonds 5Y	0.529	0.75	0.3162
	74	Government Bonds 10Y	0.454	0.6469	0.2893