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The Impact of Expansionary Monetary Policy on Norwegian Stock Prices

A Structural Vector Autoregressive Analysis of the Past Three Decades

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Acknowledgements

We became particularly interested in monetary policy and its impact on the economy after taking the courses *Crashes and Crisis*, *Money and Banking* and *Business Cycle Analysis*. This prompted us to consult with our supervisor about various aspects of monetary policy, before we eventually settled on analyzing the impact of expansionary monetary policy on stock prices.

The past months of working on this thesis have proved challenging and demanding. More importantly, it has been highly interesting and educational. We have had the opportunity to study a topic of our own choice while acquiring new knowledge.

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Abstract

This paper aims to evaluate the impact of domestic monetary policy shocks on Norwegian stock prices, as well as the impact in a historically low interest rate environment. Consequently, the analysis is comprised of (1) the baseline model from 1991:M1 to 2019:M6 and (2) the model following the financial crisis from 2009:M6 to 2019:M6. Building on Neri (2004) and Bjørnland (2009), a structural vector autoregression (SVAR) with short-run restrictions and Cholesky decomposition is utilized. The estimated models consist of the oil price, inflation, output, three-month interest rate, trade-weighted exchange rate index, and stock prices. Impulse responses and variance decomposition are used to evaluate the impact of the monetary policy shocks.

Consistent with prior research and theory, the results of the baseline model indicate a significant negative relationship between a change in the three-month interest rate and stock prices. In particular, following a 100 basis points decrease in the three-month interest rate (Nibor), stock prices (OSEBX) increase by 1 percent on impact and 2 percent after six months. Moreover, the monetary policy shock accounts for slightly less than 10 percent of the variations in stock prices after six months and roughly 20 percent after two years. These results are relatively robust to different specifications. Examining the model from mid-2009 to mid-2019, a decrease of 100 basis points in Nibor increases stock prices by 0.5 percent on impact, with the effect gradually waning over time. Therefore, the effectiveness of the monetary transmission mechanism to stock prices appears to have diminished when interest rates have been historically low. The results indeed provide updated validity to previous literature and valuable insight into the monetary policy transmission mechanism in Norway.

Keywords – Monetary policy, Stock prices, Monetary policy transmission mechanism

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1 Introduction

Since the early 1990s, interest rates in Norway have decreased substantially, reaching historically low levels in the aftermath of the financial crisis. As a small open economy with free capital movements, Norway's interest rates cannot deviate vastly from its trading partners (Norges Bank, 2021). Hence, the decline is part of a globally low interest rate environment. Bernanke (2005) and Summers (2014) contend that increased savings relative to investment may have contributed to a fall in the equilibrium real interest rate. Simultaneously, several economists attribute the low interest rates to expansionary monetary policy (Norges Bank, 2021). During the same time period, Norwegian stock prices have increased substantially. The development depicted in figure 1.1 raises questions regarding the relationship between stock prices and short-term interest rates. Specifically, how do stock prices respond when policymakers adjust the key policy interest rate? Moreover, does the effect change over time?

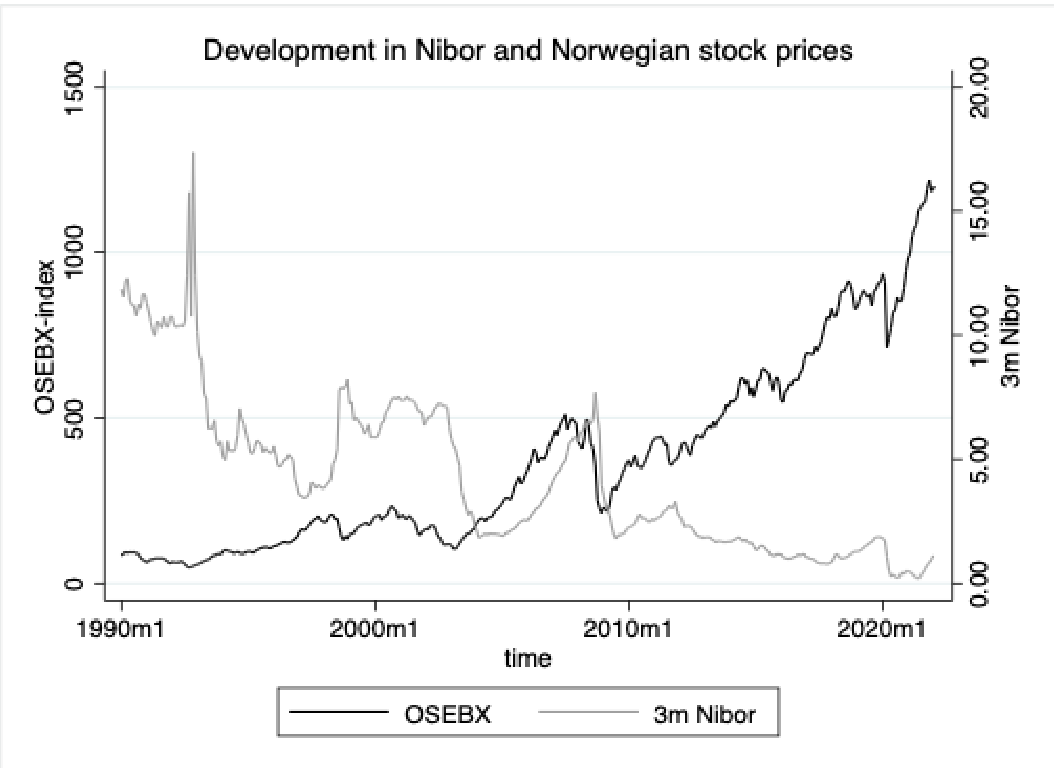

Figure 1.1: Development in Nibor and Norwegian stock prices from 1990 to 2020. Sources: Norges Bank and Oslo Børs

The relationship between monetary policy and asset prices has been especially debated since the global financial crisis of 2007-2009. The crisis demonstrated the importance of a stable financial system and how its absence could result in a severe and protracted recession. Consequently, like other countries, Norway has placed a greater emphasis on financial stability (Røisland and Sveen, 2018). Norwegian literature on this topic looks particularly into excess money supply and asset prices. For example, Grytten and Hunnes (2014) observes significant growth in stock prices along with credit and monetary expansion from July 1990 to September 1992 and before the 2008 crash.

Other studies are more centered on quantifying monetary policy's impact on stock prices. A growing body of international work employs structural vector autoregressive (SVAR) analyses when evaluating the impact of changes in the interest rate on stock prices. The studies also include variables part of the monetary policy transmission mechanism, such as inflation, output, and exchange rate. They all point to the fact that expansionary monetary policy increases stock prices. In comparison, SVAR literature on the Norwegian transmission mechanism focuses mainly on the effect on housing prices (Bjørnland and Jacobsen, 2010) and exchange rate (Bjørnland, 2008), whereas the impact on stock prices receives less attention.

Hence, uncertainty still exists regarding the relationship between monetary policy and stock prices in Norway. Therefore, this paper aims to contribute to the literature from an empirical perspective. Building on Neri (2004) and Bjørnland (2009), the thesis employs structural vector autoregressions with short-run restrictions. Our analysis attempts to offer updated validity to the literature regarding the impact of monetary policy changes on stock prices, as well as the monetary policy transmission in general.

Examining the transmission to the real economy is especially pertinent when discussing the transmission mechanism's strength or effectiveness. Since 2005, Norges Bank's monetary policy has become more open and transparent, possibly providing a more effective policy (Grytten et al., 2021). On the other hand, the transmission mechanism appears to have diminished over the past decade due to persistently low interest rates. Accordingly, Norges Bank points to the low interest rate environment as a challenge for monetary policy in achieving its objectives (Norges Bank, 2021).

1.1 Research Questions

Based on the preceding section, this thesis poses two research questions:

- *How has expansionary monetary policy impacted Norwegian stock prices over the past three decades?*
- *How has expansionary monetary policy impacted Norwegian stock prices in a historically low interest rate environment over the past decade?*

We attempt to investigate these research questions by employing two SVAR models with short-run restrictions utilizing impulse response functions. Consequently, the analysis is comprised of (1) the baseline model from 1991:M1 to 2019:M6 and (2) the model following the financial crisis from 2009:M6 to 2019:M6. The estimated models include the oil price, inflation, output, three-month interest rate, trade-weighted exchange rate index, and stock prices. The thesis is limited to looking only at the Norwegian economy.

When investigating the impact of expansionary monetary policy shocks on stock prices in the first model, we also examine the effects on additional variables. This is to determine if our model aligns with the channels of the monetary policy transmission mechanism. To underline the results, we analyze the contribution of variables to the fluctuations in stock prices. When attempting to answer the second research question, we place greater emphasis on the transmission mechanism through stock prices. That is, the impact of a monetary policy shock on stock prices and economic activity, as well as the impact of a stock price shock on economic activity. This broadens the understanding of the transmission mechanism in a low interest rate environment.

Our research questions are important to monetary policymakers as they get to how adjustments in interest rates impact stock prices. In addition, they provide valuable insight into the transmission mechanism of monetary policy in Norway when interest rates are persistently low. The relationships are also of importance to participants in the financial markets like stock market investors, as monetary policy changes can affect firm value.

1.2 Outline

The overall structure of this thesis takes the form of eight chapters, including this introductory chapter. Chapter 2 provides an overview of the historical Norwegian monetary policy regimes, emphasizing current inflation targeting. The third chapter outlines the theoretical elements of the monetary policy transmission mechanism, as well as the relationship between stock prices and interest rates. Chapter 4 summarizes the existing international literature on the topic when utilizing vector autoregression analysis and the interplay between Norwegian stock prices and monetary policy. In chapter 5, the collection and processing of data are presented while elaborating on validity and reliability. In addition, the Hodrick-Prescott (HP) filter is presented, as this is one of our primary data processing approaches. The sixth chapter is concerned with the methodology employed in this study, regression specifications, and its assumptions. Furthermore, chapter 7 offers our findings and discussions, as well as robustness tests and shortcomings of the results. Finally, the last chapter draws upon the entire thesis by providing suggestions for future research, followed by concluding remarks.

2 Institutional Background

The purpose of this chapter is to provide a brief overview of Norway's road to inflation targeting and the patterns underlying Norges Bank's fundamental objectives, as expressed in the Monetary Policy Regulation.

2.1 Norway's Road to Inflation Targeting

Norway has a long history focusing on exchange rate stability, dating back to the silver standard in the middle of the 19th century (Soikkeli, 2002). Following World War II, there was a fixed exchange rate regime in which the Norwegian krone was tied to the American dollar, which was pegged to gold, also referred to as the Bretton Woods System. However, the Bretton Woods regime collapsed in 1972, and Norway endured nearly fifteen years of high inflation. Multiple devaluations of the krone were insufficient to reduce unemployment. The long period of high inflation demonstrated that the economic policy framework was not functioning as intended, proving evidence of the importance of a nominal anchor. Consequently, the exchange rate in 1986 was fixed against a trade-weighted basket of currencies until 1990, with the fixed exchange rate functioning as the nominal anchor. From 1990 to 1992, the Norwegian krone was pegged to the European currency unit (Soikkeli, 2002). However, when an international wave of currency speculation hit Norway in the autumn of 1992, the central bank opted to devalue the currency and suspend the fixed exchange rate (Grytten, 2020b). Until 1998, Norway's economy grew faster than those of other nations due to optimism and high oil and gas prices. However, in 1998, petroleum revenues fluctuated widely due to internal disagreements among OPEC members, depreciating the krone (Grytten, 2020b). Although the interest rate was raised several times in 1998, it served as a challenge to change the interest rate to cope with the exchange rate fluctuations (Gjedrem, 2008).

These challenges stirred up a debate on whether the country should change to an inflation-targeting regime, and Norges Bank gradually gave greater weight to influencing inflation (Soikkeli, 2002; Gjedrem, 2008). Moreover, there was an increasing global consensus that monetary policy should contribute to low and stable inflation. In 1991, New Zealand was the pioneer to adopt inflation targeting and let their exchange rate float, followed by

Canada (1991), the United Kingdom (1992), and Sweden (1993). Norway's transition to inflation targeting did, however, require more time. In 1999, Svein Gjedrem took over the helm as governor of Norges Bank and was at the forefront of the monetary policy shift to inflation targeting in Norway. This suggested that Norges Bank's operational goal became maintaining low and stable inflation, similar to the objective of Eurozone member countries (Gjedrem, 2008).

2.2 The Inflation Targeting Regime

As of today, Norges Bank's monetary policy mandate is outlined in the Central Bank Act and the Monetary Policy Regulation (Norges Bank, 2021). The primary objectives are articulated in the Regulation on Monetary Policy of December 2019:

1. Monetary policy shall maintain monetary stability by keeping inflation low and stable.
2. Norges Bank is responsible for the implementation of monetary policy.
3. The operational target of monetary policy shall be annual consumer price inflation of close to 2 percent over time. Inflation targeting shall be forward-looking and flexible so that it can contribute to high and stable output and employment and to counteracting the build-up of financial imbalances.
4. Norges Bank shall regularly publish the assessments that form the basis of the implementation of monetary policy.

The primary objectives result from the adjustment of monetary policy implemented during the past decades. Norges Bank Watch summarizes particularly three trends in the Norwegian flexible inflation targeting over the past twenty years: (1) monetary policy has been continuously more flexible, (2) the monetary policy processes have been more open and transparent and (3) emphasis has been placed on financial stability (Grytten et al., 2021).

Firstly, adjustments in the time horizons and parameters impacting policy management show increasing flexibility in monetary policy. In March 2001, the inflation target was established at 2.5 percent, and it was made clear that the inflation targeting should be flexible (Norges Bank, 2022a). The inflation is measured by the underlying inflation, CPI-ATE, developed in December 2003 by Statistics Norway (SSB). CPI-ATE is the consumer price index (CPI) adjusted for changes in indirect taxes and excluding energy production (SSB, 2022a). In 2005, however, the target horizon was adjusted from 1 to 3 years to medium-term due to concerns about overheating of the economy and asset bubbles. Later, in March 2018, the inflation target was reduced from 2.5 percent to 2 percent. The target was changed due to the phase-out of the petroleum sector, which reduced inflation pressure from the industry. Consequently, there were no arguments for not having the same target level as trading partners. At the same time, the third objective in the Regulation on Monetary Policy was stated (Grytten et al., 2021).

Secondly, greater transparency emerged in response to a higher demand for more openness due to the central bank's instrument- and goal independence. Norges Bank's informative publications that assured some transparency in the 1990s were not sufficient, requiring monetary policy to be handled with greater transparency (Stoltz et al., 2022). Therefore, as one of the world's first central banks, Norges Bank began publishing the forecast of the interest rate path in 2005. Thus, the market would be aware of the anticipated direction of the key policy rate and could adjust before the central bank implemented its policy change. Since markets adapt to expectations, households and businesses could make more optimal choices and investments (Grytten et al., 2021). As of today, Norges Bank publishes the Monetary Policy Report four times a year, including the policy rate path (Norges Bank, 2022b).

Finally, experiences from the global financial crisis in 2007-2009 emphasized the importance of taking financial stability into account (Røisland and Sveen, 2018). Prior to the financial crisis, the central bank set low key policy interest rates in line with a relatively strict focus on inflation targeting. This caused the economy to overheat and asset bubbles to occur. Although the central banks raised the key policy interest rate between 2006 and 2008, it appeared to be too late (Grytten et al., 2021). The crisis highlighted the importance of a stable financial system and how its absence could lead to a deep and long-lasting recession. As a result, managing financial variables were observed to be of great importance, and financial stability gained more focus globally, with Norway being no exception (Røisland and Sveen, 2018). Controlling financial stability in Norway is currently shared amongst three units: The Ministry of Finance, Finanstilsynet, and Norges Bank (Norges Bank, 2020a). The Ministry of Finance is primarily responsible for maintaining a well-functioning financial industry in Norway, while Finanstilsynet is responsible for solidity, control, and management in the financial institutions and supervises the actors. Finally, Norges Bank is responsible for promoting financial stability in the financial system and ensuring a well-functioning payment system (Norges Bank, 2020a).

3 Theory

Using the model of Røisland and Sveen (2018), this chapter describes the effect of monetary policy on inflation, economic activity, and financial stability in a small open economy. Moreover, Mishkin (2001), Tobin (1965) and Mundell (1963) augment the transmission mechanism by elaborating on how interest rates impact stock prices. The discounted cash flow (DCF) model and efficient market hypothesis (EMH) then illustrate the effect of changes in interest rates and new information on stock valuation. Nonetheless, the chapter begins by defining business cycles and Nibor.

3.1 Business Cycles

The economy's expected growth path, or underlying growth in the gross domestic product (GDP), is referred to as its trend (Grytten and Hunnes, 2016). If all input factors are fully utilized, the economy grows according to the trend. However, actual development in GDP usually deviates from the expected growth path, as portrayed in figure 3.1. These deviations from the trend are referred to as fluctuations or business cycles. When the growth path is upward sloping, the economy is undergoing an expansion. Likewise, the economy is in a recession phase when the growth path is downward sloping. Moreover, the percentage gap between actual GDP and trend is known as the output gap. If the output gap is positive, actual output exceeds potential output, contributing to inflation. On the other hand, a negative output gap indicates that actual output is below potential output. This could result in unemployment if input elements are not adequately utilized (Grytten and Hunnes, 2016).

The turning points follow the definition of the classical business cycles. Classical cycles have turning points at the local maximum (peak) and minimum (trough) points of the trend-cyclical curve, implying that $\frac{dy}{dt} = 0$. The turning points of the growth cycles, on the other hand, occur when the cycles grow at the same rate as the trend, implying that $\frac{dy}{dt} = a$ where a is the trend's growth rate (Aschutan, 2022). In section 5.2 in the chapter on Collection and Processing of Data, we describe how the Hodrick-Prescott filter separates the trend from the cycle.

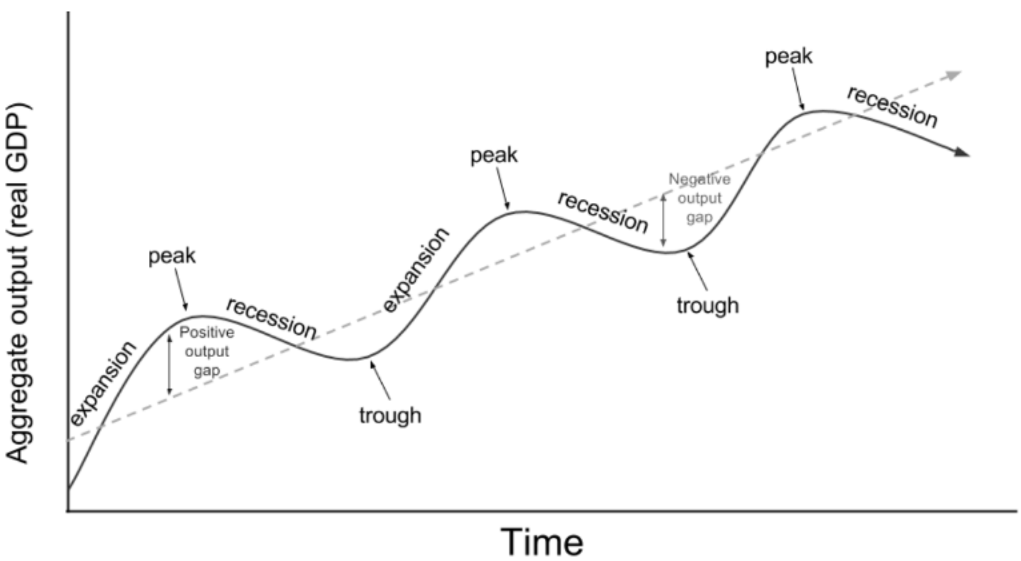

Figure 3.1: Business Cycles, adapted from Khan Academy (2022).

3.2 Norwegian Interbank Offered Rate

The Norwegian Interbank Offered Rates (Nibor) are a set of Norwegian money market interest rates serving as reference rates for loans with maturities other than overnight (NoRe, 2019). Although quoted at different maturities, the three-month Nibor (3m Nibor) is the most important. The rates reflect the cost of an unsecured loan in NOK between Norwegian banks in the Norwegian money market. A panel of six banks reports their best estimate of the cost of borrowing, and the highest and lowest value is omitted (NoRe, 2019). Nibor is then computed as the simple average of these interest rates.

Nibor is constructed as a currency swap rate derived from a dollar interest rate and the interest rate differential between American dollars (USD) and Norwegian kroner (NOK) (Tafjord, 2015). First, the panel banks provide their best estimate on the cost of borrowing USD in the unsecured interbank market. Furthermore, the loans are swapped from USD to NOK by adjusting the interest rate differential between the two currencies. This results in Nibor being an indicative and implicit rate in NOK. A way of decomposing Nibor is to express the rate as the market's expectations of the key policy interest rate plus a risk premium (Tafjord, 2015):

$$\text{3m Nibor} = \text{Three months expected key policy rate} + \text{risk premium} \tag{3.1}$$

The three-month expected key policy rate depends on the current interest rate and interest rate path, estimated and communicated by the central bank. The risk premium is the excess return banks demand when lending reserves to one another in the interbank market rather than depositing them risk-free in Norges Bank at the key policy rate. Nibor tends to follow the key policy interest rate slightly higher since the risk premium is positive. This is illustrated in figure 3.2. However, the two variables may not always coincide perfectly. For example, the central bank can lower the key policy interest rate without managing to reduce Nibor to the desired level due to uncertainty in the market, consistent with high-risk premiums. Moreover, if Norges Bank lowers its key policy rate and Nibor does not decrease accordingly, the interest drop may have already been reflected in the market (Tafjord, 2015).

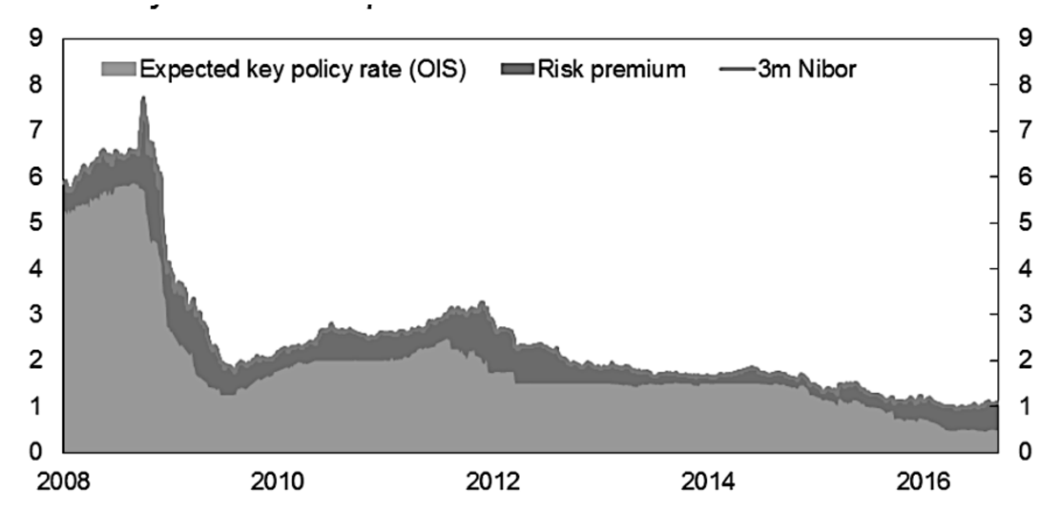

Figure 3.2: Construction of Nibor, adapted from Tafjord (2015).

3.3 Monetary policy under inflation targeting

Røisland and Sveen (2018) present a model describing the inflation targeting regime in a small open economy. A small open economy participates in international trade but is small in comparison to its trading partners, such that its policies have a negligible effect on global prices, interest rates, and income. Consequently, the inclusion of the real exchange rate is a critical component in the model. Furthermore, the model is static, describing the effect after the monetary policy has worked through the economy, usually within 1 to 3 years. This is in line with the common assumption that monetary policy only temporarily impacts the real economy. In the short run, the monetary policy seeks to stabilize demand around the level consistent with normal resource utilization, or potential output. However, monetary policy cannot alter the output in the long run because the output is determined by technology, preferences, and production factors (Røisland and Sveen, 2018).

The real exchange rate

To determine the exchange rate in the open economy, one starts with the uncovered interest rate parity (UIP) equation, defining the nominal exchange rate (Røisland and Sveen, 2018):

$$s = s^e - (i - i^*) + z \tag{3.2}$$

where s^e is the expected nominal exchange rate in the next period, i is the domestic interest rate, i^* is the interest rate abroad, and z is a shock to the currency. Equation 3.2 states that the nominal expected return in two currencies should be equal because changes in the nominal exchange rate and nominal return would offset each other. By rewriting the equation into real form, the real exchange rate can be expressed as:

$$e = e^e - (r - r^*) + z \tag{3.3}$$

where $r^* = i^* - \pi^{*,e}$ is the foreign real interest rate and $\pi^{*,e} = p^{*,e} - p^*$ is expected foreign inflation. Equation 3.3 states that appreciation or depreciation of the real exchange rate depends on the real exchange rate of another currency, and the relationship between the changes in the real return of the two economies (Røisland and Sveen, 2018).

3.3.1 The Investment-Savings Curve

The demand side of the economy is described by the Investment-Savings (IS) curve, which is the traditional Keynesian demand function. It takes the form of the following equation, where y is the output gap:

$$y = -a_1(i - \pi^e - \rho) + a_2 e + v \tag{3.4}$$

$(i - \pi^e)$ represents the real rate, i.e., the nominal interest rate minus expected inflation. ρ is the long-run equilibrium real interest rate, a_1 and a_2 are weighting constants, and v is a demand shock. The curve shows the set of all interest rates and output where total investment equals total savings in the economy.

According to equation 3.4, the output gap reacts negatively to increased real rate and positively to decreased real rate; the parameter a_1 measures the magnitude of the effect. When the interest rate decreases, more investment projects are profitable due to a lower cost of borrowing and a lower discount rate. Additionally, demand for goods and services increases as the return of savings and the cost of bearing interest on loans decreases. Therefore, the central bank can influence demand by altering market interest rates through lending rates and market communication changes. Its efficiency depends, among other things, on the transparency and openness of the central banks' communication. Consequently, Norges Bank (2021) states that forward guidance and forecasts are important tools in the transmission of monetary policy, in addition to the key policy rate.

Moreover, the exchange rate impacts the production gap. For instance, the activity level increases when the real exchange rate increases, also referred to as real domestic currency depreciation. Consequently, domestically produced goods and services turn relatively less expensive, increasing the demand at the strength measured by a_2 (Røisland and Sveen, 2018).

3.3.2 The Phillips Curve

The supply side of the economy, the Phillips curve (PC), is described by the following equation:

$$\pi = \pi^e + \gamma_1 y + \gamma_2 e + u \tag{3.5}$$

stating that expected, domestic, and imported inflation influence total inflation (π). γ_1 and γ_2 are weighting constants, whereas u represents an inflation shock. The Phillips

Curve is based on the assumption of price rigidity in the short run, suggesting that increased demand leads to a gradual increase in price levels (Philips, 1958). Increasing demand for goods and services increases price levels. Moreover, firms will increase their activity levels to meet the increased demand, leading to higher firm costs and wages. The real exchange rate also impacts total inflation due to imported inflation in an open economy. When the real exchange rate depreciates, imported goods turn more expensive, resulting in rising inflation (Røisland and Sveen, 2018).

3.3.3 Optimal Monetary Policy

The key policy interest rate is Norges Bank's most important instrument for achieving its 2 percent inflation target and responding to economic shocks. An explicit inflation target also provides economic actors with an anchor for inflation expectations. The inflation targeting policy can be illustrated through a loss function, described by Røisland and Sveen (2018):

$$L = \frac{1}{2}((\pi - \pi^*)^2 + \lambda y^2) \tag{3.6}$$

Equation 3.6 depicts the total economic loss that the central bank seeks to minimize by keeping inflation at its target rate and minimizing deviations from potential output. A loss occurs if there is a gap between actual inflation and the inflation target, the inflation gap ($\pi - \pi^2$), or a gap between actual production and potential production, the output gap (y). Lambda (λ) denotes the weight the central bank assigns to minimize the output gap relative to the inflation gap. A positive value of lambda suggests that the inflation targeting is flexible, such that both inflation and production are considered when determining the key policy interest rate. Furthermore, the gaps are squared since both positive and negative gaps result in equal losses and more significant gaps have a proportionally greater impact on the economy than smaller gaps.

The loss function can be illustrated by indifference curves, as displayed in figure 3.3. The circles represent indifference curves, showing inflation and output gap combinations that yield unchanged losses. When inflation is at the target level of 2 percent and the output gap is zero, the total loss is zero. Indifference curves further away from the target indicate a more considerable loss. For instance, L_2 causes a higher loss than L_1. The central bank is indifferent to every combination of inflation and output levels at each circle since they result in the same loss. The figure on the right has a lower lambda value, resulting in flatter indifference curves, as the central bank is more concerned with inflation targeting. One can expect greater output variation than inflation variation in such a scenario since inflation fluctuations are more "costly" Røisland and Sveen (2018).

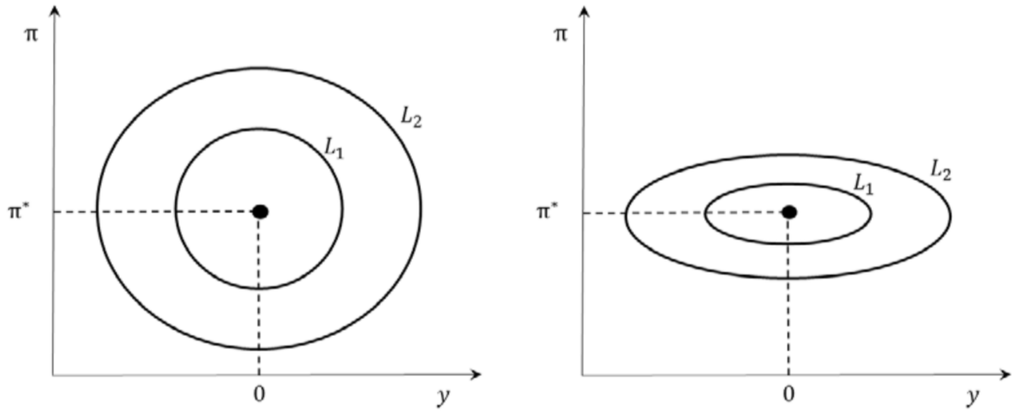

Figure 3.3: Indifference curves, adapted from Røisland and Sveen (2018).

The monetary policy curve

By minimizing the loss function, the central bank sets the interest rate. The first-order condition, or the monetary policy curve, is then reflected by the following equation:

$$(\pi - \pi^*) = -\frac{\lambda}{(\gamma_1 + \frac{\lambda_2}{(a_1+a_2)}} y \qquad (3.7)$$

The monetary policy (MP) curve illustrates how minimizing the inflation gap comes at the expense of the output gap. A negative sign in front of the right-hand equation indicates that the two gaps must have opposite signs. If both gaps are positive, the central bank could easily improve the situation by raising the interest rate, reducing both gaps. Put differently, the equation states the central bank's willingness to drive the economy into a boom when inflation is too low. This depends on how much the central bank dislikes the gap (λ) and how easy it is to control inflation by increasing or decreasing the output gap (γ_1). The additional term, $(\frac{\lambda_2}{(a_1+a_2)})$, reflects the fact that the central bank can influence inflation through both the direct and indirect channels. For instance, a lower interest rate may increase the real exchange rate, increasing inflation. γ_2 measures the importance of imported inflation.

3.3.4 The Monetary Policy Transmission Mechanism

The dynamics of the Røisland and Sveen model (2018) are summarized in the monetary policy transmission mechanism, describing the process by which monetary policy is transmitted to real economic activity and inflation. Since the model assumes constant inflation expectations, nominal and real interest rates have a short-term one-to-one relationship. This is due to temporarily sticky inflation and inflation expectations. In contrast, if prices were flexible, real interest rates would remain unchanged after a monetary policy shock. The four channels outlined by Røisland and Sveen (2018) are portrayed in figure 3.4, and are as follows:

1. The interest rate channel to aggregate demand
2. The aggregate demand channel to inflation
3. The exchange rate channel to aggregate demand
4. The direct exchange rate channel to inflation

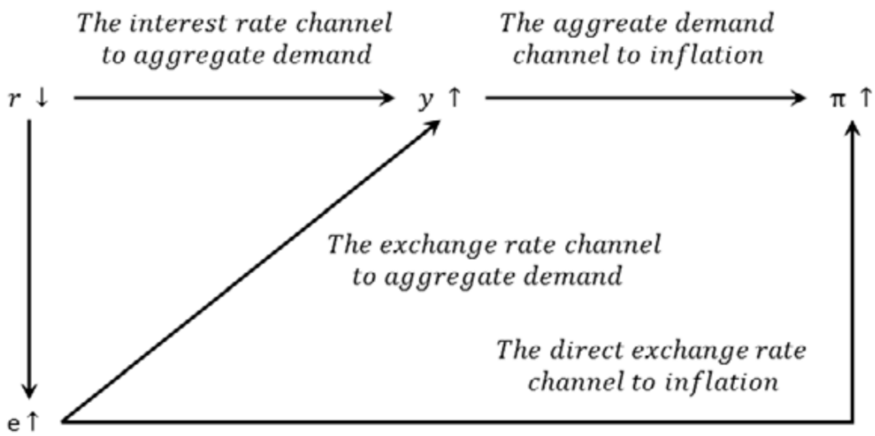

Figure 3.4: The monetary policy transmission mechanism, adapted from Røisland and Sveen (2018).

The interest rate channel to aggregate demand, and the aggregate demand channel to inflation

The key policy interest rate is the rate that Norwegian banks receive on their deposits in Norges Bank up to a set quota (Norges Bank, 2022b). Changes in the key policy rate further impact the interest rates charged by Norwegian banks when lending and depositing money in the interbank market. When the banks' funding costs are changed, the interest rates Norwegian banks charge the public for loans and deposits are also adjusted.

Hence, reducing the key policy interest rate makes bank loans more affordable. In addition, depositing money is less attractive when interest rates are low. The number of profitable investments also increases since the discount rate of new projects decreases Røisland and Sveen (2018). Consequently, a reduction in the interest rate stimulates the public sector to increase their lending, as well as demand for goods, services, and investment. This is the interest rate channel to aggregate demand. Due to increased economic activity, price levels are likely to rise, given that demand exceeds supply. Furthermore, greater aggregate demand may give a rise in wages due to increased corporate activity and low unemployment, contributing to a more competitive labor market (Røisland and Sveen, 2018). This is the aggregate demand channel to inflation.

The direct exchange rate channel to inflation and the exchange rate channel to aggregate demand

Households consume both domestically produced goods and services as well as imported goods. When the real interest rate falls relative to the foreign interest rate, the real exchange rate depreciates since UIP is assumed to hold. Hence, imported goods turn more expensive, adding to rising inflation. This is how the mechanism of the direct exchange rate channel to inflation works. Furthermore, currency depreciation provides the home country with a competitive advantage since domestic prices are lower than foreign prices. As a result, the competition in the market for domestically produced goods and services rises, and domestic activity increases. The mechanism is the exchange rate channel to aggregate demand (Røisland and Sveen, 2018).

3.3.5 Financial Stability

Avoiding financial imbalances is important to promote economic stability over time (Norges Bank, 2021). Therefore, if financial instability rises, the central bank may raise the policy rate above the level consistent with maintaining high and stable output and employment in the short term. Such a policy is referred to as leaning against the wind (LAW). An expansion of the loss function presented above illustrates how the central bank considers financial stability in their Monetary policy strategy by including the financial variable q (Røisland and Sveen, 2018):

$$L = \frac{1}{2}(\pi - \pi^*)^2 + \lambda y^2 + \delta q^2 \tag{3.8}$$

where δ is the weight assigned to financial stability relative to other parameters, and q is a financial variable containing factors such as credit supply, housing prices, or debt. If q exceeds its equilibrium value, the economy suffers a loss due to financial instability. Maintaining financial stability thus comes at the expense of either reducing inflation- or the production gap. The financial variable is expressed as follows:

$$q = -\phi(r - \rho) + w \tag{3.9}$$

Equation 3.9 states that the financial gap depends on the real interest rate, and its dependence is denoted by ϕ. w represents financial shocks independent of the real rate changes. As suggested by the inverse relationship between the real rate and q, a decrease in the real rate causes a rise in the financial variable.

3.4 The impact of Monetary Policy on Stock Prices

3.4.1 Stock Prices in the Monetary Transmission Mechanism

Theories postulated by Mishkin (2001), Mundell (1963) and Tobin (1965) augment the transmission mechanism by explaining how the key policy interest rate impacts stock prices. Mishkin (2001) illustrates the impact of interest rates on the real economy through three asset classes: stock prices, real estate prices, and exchange rates. In line with the research questions of the thesis, the focus will be on stock prices. Following Mishkin (2001), equation 3.10 depicts the transmission mechanism via stock prices. According to the equation, expansionary monetary policy leads to an increase in stock prices. Thereafter, Tobin's q increases and stimulates investment, aggregate demand, and output.

$$M \Uparrow \rightarrow P \Uparrow \rightarrow q \Uparrow \rightarrow I \Uparrow \rightarrow Y \Uparrow \tag{3.10}$$

There are several reasons why expansionary monetary policy influences stock prices. For instance, Mishkin (2001) asserts that when interest rates are lowered due to expansionary monetary policy ($M \Uparrow$), bond prices decline. Since bond prices are lower than equity prices, stocks are more enticing than bonds. This raises the demand and prices of stocks ($P \Uparrow$). Moreover, Mundell (1963) and Tobin (1965) put forward the point that changes in interest rate may impact households' savings in assets, suggesting that some of the real effects of monetary policy operate through the stock market. They contend that a lower key policy interest rate reduces the alternative cost of investing in non-interest-bearing assets since the interest rate on bank deposits is reduced. Consequently, households are more likely to invest in assets yielding a higher return, shifting their wealth from savings in bank accounts to assets such as stocks, thereby increasing stock prices. This effect has been demonstrated to affect the wealthiest portion of the population, primarily (Sterk and Melkangi, 2020).

Furthermore, Mishkin (2001) suggests that rising stock prices lead to increased investment spending ($\Uparrow I$), followed by higher aggregate demand and output ($\Uparrow Y$). Tobin's q (Tobin, 1969) explains the relationship between stock prices and investment:

$$q = \frac{\text{Market value of real capital}}{\text{Replacement cost of real capital}} \tag{3.11}$$

If q is greater than 1, the market value of real capital exceeds the replacement cost of real capital. Therefore, real capital is less expensive than the market value of implemented real capital. In such circumstances, firms frequently issue stocks to raise more capital and expand their investment level (Mishkin, 2001).

Another effect impacting the transmission mechanism through stock prices is asymmetric information in credit markets. Since the effect works through the firms' balance sheet, the mechanism is also known as the balance sheet channel. Asymmetric information in the credit markets makes the firm's net worth a critical determinant of the amount of credit the firm can borrow. For instance, lower net worth indicates that the firms are more likely to take on risky investments, making banks less willing to lend to them. In contrast, a higher net worth lessens the risk for banks, allowing them to lend more. As illustrated below, the expansionary policy increases stock prices, increasing the firms' net worth ($NW \Uparrow$). The rise of firms' net worth makes the firms more attractive borrowers, increasing lending ($L \Uparrow$). Consequently, the firm's investments, aggregate demand, and production increase (Mishkin, 2001).

$$M \Uparrow \rightarrow P \Uparrow \rightarrow NW \Uparrow \rightarrow L \Uparrow \rightarrow I \Uparrow \rightarrow Y \Uparrow \tag{3.12}$$

The Balance sheet channel can also be applied to households, as stocks and other financial assets constitute a significant portion of the assets of numerous households. When stock prices increase due to expansionary monetary policy, households become wealthier ($W \Uparrow$). This increases consumption ($C \Uparrow$), production, and output in the real economy, as follows:

$$M \Uparrow \rightarrow P \Uparrow \rightarrow W \Uparrow \rightarrow C \Uparrow \rightarrow Y \Uparrow \tag{3.13}$$

3.4.2 The Discounted Cash Flow Model

The discounted cash flow (DCF) model determines the equity value of a firm, or the stock price (Møller and Kaldestad, 2016). According to the model, a company's enterprise value is calculated as follows:

$$V_0 = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + ... + \frac{CF_n}{(1+r)^n} \tag{3.14}$$

where CF_n is the expected cash flow in year n and r the firm's cost of capital, or the discount rate. According to equation 3.14, the firm's value equals the sum of its discounted expected cash flows over its lifetime. To determine the value of the firm's equity, the debt value is deducted from the enterprise value. Finally, the stock price is determined by dividing the equity by the number of outstanding shares (Møller and Kaldestad, 2016).

The effect of the interest rate in the DCF-model:

The extent to which interest rate changes are reflected in stock prices depends on the market's efficiency. Malkiel (1989) states that "a marked is said to be efficient with respect to an information set, (ϕ) if security prices would be unaffected by revealing that information to all participants.". The degree of market efficiency is usually categorized by three forms: weak, semi-strong, and strong form, determined by the nature of the information set (Maverick et al., 2022). A weak form of market efficiency is present if the information set includes the historical price information. A semi-strong financial market suggests that the information set includes all publicly available information, as well as the historical price information. Finally, there is a strong form of market efficiency if the information reflects all information known to any market participant (Maverick et al., 2022). This suggests that both private and public information is reflected in the prices, such as private information only known to a company's CEO.

In practice, markets cannot be entirely efficient or inefficient (Hall, 2022). It may be reasonable to view markets as a combination of all three. Following a semi-strong financial market, stock prices react immediately to public news, regarded as new information. On the contrary, if the public anticipates interest rate changes, stock prices may remain stable because they already reflect the change. When utilizing the DCF-model, the magnitude of the impact of an interest rate change on stock prices is determined by the market's efficiency and whether or not the information is new.

It follows from equation 3.14 that a monetary policy change can affect the stock price through both a direct and an indirect effect (Kontonikas and Ioaniddis, 2008). The direct effect is by the discount rate, also known as the firm's cost of capital (r), assuming that the discount rate is tied to the market rates, which the central bank can influence. Furthermore, the indirect effect affects the firm's value through the expected future cash flows (CF). As in the transmission mechanism, this effect assumes a relationship between monetary policy and the aggregate real economy.

The direct effect of monetary policy

The direct effect works through the firm's cost of capital (r), which can be calculated as the firm's weighted cost of capital (r_{WACC}) (Møller and Kaldestad, 2016; Kontonikas and Ioaniddis, 2008):

$$r_{WACC} = \frac{E}{(E+D)} * r_e + \frac{D}{(E+D)} * r_d * (1-t) \tag{3.15}$$

where E is the market value of equity, D the net financial debt, r_e the cost of equity, r_d the cost of debt and t the tax. From the equation, it follows that the firm's average cost of capital depends on the firm's amount of debt and equity and its costs. Hence, the cost of capital is influenced by monetary policy changes both through the impact on (1) the cost of equity and (2) the cost of debt.

Two important components when estimating the cost of equity are the risk-free rate and the market risk. In Norway, the risk-free rate is usually based on the interest rate on government bonds (Møller and Kaldestad, 2016). Government bond interest rates are closely tied to the key policy interest rate. Consequently, a decrease in the interest rate results in a lower cost of equity, holding everything else constant. Hence, stock prices increase. Moreover, the risk premium is the additional return that stock market investors receive beyond the risk-free rate (Bernanke and Kuttner, 2004). The premium is dependent on market expectations and involves factors such as business cycle risk, unemployment rate, and inflation level. It typically rises when interest rates are low. This results from increased market uncertainty and investors viewing stocks as riskier, primarily due to increased volatility during a downturn. Therefore, expansionary monetary policy may influence the cost of equity in a dual manner. Firstly, stock prices rise when the risk-free rate decrease. In contrast, higher risk premiums can cause them to fall. The most substantial effect determines the full effect.

The cost of debt is the interest rate paid by firms to creditors on their debt, typically bank loans or obligations (Møller and Kaldestad, 2016). As described in section 3.3.4, lowering the key policy interest rate affects the bank's lending rate via Nibor. In addition, Nibor is quite dependent on international interest rates, as Norwegian banks often are funded through international money markets (Hall, 2001). Accordingly, business cycles in other large economies also impact the credit risk premium in Norway. Furthermore, the firm's risk of default or credit ranking influences its loaning rate, which generally rises during economic downturns. As with the cost of equity, a lower interest rate reduces the cost of debt, raising the firm's stock price. On the other hand, uncertainty in the market and increased risk premiums negatively affect the stock price.

The indirect effect of monetary policy

The indirect effect works through the company's expected future cash flows (Kontonikas and Ioaniddis, 2008). These expectations are contingent on the expected interest rate path and changes in the key policy rate since interest rates are related to economic growth. Following the monetary policy transmission mechanism, a change in monetary policy impacts economic growth within 1 to 3 years. For instance, Patelis (1997) argues that stocks are claims on future economic output. Consequently, if monetary policy impacts the real economy, monetary conditions should influence stock prices. Furthermore, future economic activity expectations affect the expected cash flows of the companies (Kontonikas and Ioaniddis, 2008). For example, if economic growth is expected to increase, firms' revenue is likely to increase when they sell more units or increase earnings per unit sold, increasing cash flows. Consequently, one can anticipate higher cash flows followed by expansionary monetary policy, resulting in increased stock prices.

4 Literature Review

The first section of this chapter examines international empirical research on the influence of monetary policy on stock prices, utilizing vector autoregressive and structural vector autoregressive methodology. The primary reason for focusing on VAR and SVAR literature is that it allows us to build on previous studies when identifying our model and facilitates the comparison of our results. In addition, the impact of monetary policy on other economic variables such as gross domestic product and inflation are included as they are essential in the monetary policy transmission mechanism. However, the VAR literature on the relationship between the Norwegian stock market and monetary policy is somewhat limited. Consequently, the second section provides a more comprehensive Norwegian literature review of this relationship, utilizing a variety of methodologies.

The literature generally supports the notion that monetary policy can significantly impact stock prices. In particular, expansionary monetary policy increases stock prices while contractionary monetary policy decreases stock prices. On the other hand, the results differ in magnitude, timing, and persistency.

4.1 International Literature utilizing VAR

The effect of monetary policy has to a large extent, been addressed through VAR and SVAR models, introduced by Sims (1980). Initially, the literature focused mainly on the impact of the Fed's monetary policy on the stock market in the United States (US). Since then, there have also been studies on the stock market in advanced and emerging economies.

In the late 1990s, Thorbecke (1997) estimates a VAR model using a Cholesky scheme, imposing a recursive ordering of the identified shocks in the US. From 1967 through 1990, the analysis covers monthly data on real equity returns, output growth, inflation, and the federal funds rate. The study discovers that a positive monetary policy shock has a significant negative effect on stock prices by an average of 0.8 percent per month, or 10 percent annually. In addition, the analysis indicates that monetary policy accounts for an average of 3.94 percent of the 24-month forecast variation in stock returns. A few years later, Rapach (2001) observes the effects of monetary policy shocks on real stock prices in the US, employing solely long-run restrictions in the SVAR model. Quarterly data on output level, nominal interest rate, price level, and the S&P 500 index are included from 1959 to 1999. The analysis concludes that an expansionary monetary policy shock causes a short-run increase in real stock prices and that monetary policy accounts for 30 percent of the variance in real stock prices within a year.

Recent studies appear to be more concentrated on distinguishing between monetary policy's immediate and long-term effects on stock prices. Bjørnland and Leitemo (2009) investigates the interdependence between US monetary policy shocks and stock prices from 1982 to 2002. The model identification is a Cholesky scheme with both short-run and long-run restrictions. Monthly statistics on the consumer price index, commodity price index, industrial production index, federal funds rate, and stock price index of the S&P 500 in the US are all included in the study. In contrast to Thorbecke (1997) and Rapach (2001), Bjørnland and Leitemo (2009) discover a relatively large and significant interdependence between a monetary policy shock and real stock prices. According to the findings, a 100 basis points increase in the federal funds rate causes an immediate 9-percentage-point drop in stock values, whereas the effect gradually fades.

Studies utilizing data from nations other than the US primarily examine developed countries. In one such study, Neri (2004) estimates a SVAR analysis of the G7 countries by using short-run restrictions. The included variables are real equity prices, interest rate, output, price level, exchange rate, and nominal money stock. Since the G7 countries are small open economies, Neri emphasizes the importance of including the exchange rate to better identify monetary policy shocks. According to the study, a contractionary monetary policy shock decreases the stock market index in every country except France, where the effect is negligible. However, the effects' magnitude, timing, and persistence vary across countries. This is demonstrated by the impact of a one-percentage-point increase in the key rate on stock prices. The trough varies by country from 0.1 to 6.3 percent and is reached between 2 and 12 months. While the effect is observed to be transient in Germany and the US, it is more persistent in Italy, the UK, Japan, and Spain (Neri, 2004).

Li et al. (2010) examine the disparities between the stock market's reaction to changes in monetary policy in Canada, a small open economy, and the US, a large closed economy. The analysis employs a SVAR model with short-run restrictions, including real output, price level, money supply, key policy rate, oil price, and stock prices from 1988 to 2003. The main finding is that the effect of a monetary policy shock is large and persistent in the US, while the response is small and less persistent in Canada. The immediate effect of a 25 basis points increase in the domestic interest rate on Canadian stock prices is 0.003 percent, the four-month trough in stock prices is 0.8 percent, and the effect after four months is 0.003 percent. In contrast, the immediate effect in the US is 0.55 percent, the trough at 4 percent occurs 17 months after the shock, and the decline persists for 37 months.

The preceding studies also measure how other economic indicators react to changes in monetary policy. Generally, the studies find that counteractive monetary policy reduces output levels and that monetary policy influences the exchange rate. Although the literature's findings broadly support the monetary policy transmission mechanism channels, the presence of a price puzzle stands in contrast to macroeconomic theory. An initial rise in price levels following a contractionary monetary policy in the models is referred to as the price puzzle phenomenon. For instance, Bjørnland and Leitemo (2009) shows that while an increase in the key policy rate causes output level to drop, inflation starts increasing on impact before declining after 4-6 months.

Recently, the VAR framework has been utilized to examine the impact of a low interest rate environment on the transmission mechanism's effectiveness. Borio et al. (2021) discovers, through a SVAR framework, that the monetary transmission to economic activity is substantially weaker in a zero-lower bound (ZLB) interest rate situation. Namely, the longer the interest rates remain low, the weaker is the effect of monetary policy. Moreover, a factor augmented VAR was employed in 2020 to examine the impact of a ZLB environment in the Euro-Area (Boucher et al., 2020). According to the study, the ZLB and the unconventional monetary policy tools deployed since 2009 reduce the efficiency of monetary policy in the Euro-Area.

4.2 Literature on the Norwegian Economy

History demonstrates that the relationship between Norway's expansionary monetary policy and stock prices has always been of great importance. One example is the banking crisis of 1988 to 1993, characterized by financial instability. Prior to the banking crisis, money supply and total loans increased relative to GDP, resulting in a rise in stock prices until the market plunged on Black Monday in October 1987 (Eitrheim et al., 2016). In addition, Bjørsvik et al. (2013) assert that low interest rates combined with tax deduction policy caused negative real interest rates prior to the crisis. Consequently, these factors played a significant role in monetary and credit expansion, thereby contributing to the banking crisis.

Moreover, the relationship between monetary policy and stock prices is discussed in an article examining the anatomy of financial crises in Norway from 1830 to 2010 by Grytten and Hunnes (2014). Among the findings is significant growth in stock prices from July 1990 to September 1992 and before the crash of 2008, accompanied by expansionary monetary policy measured by increased credit amount and money expansion. For instance, stock prices fell by 64 percent between May and November 2008 (Grytten, 2020b). Furthermore, Grytten et al. (2021) raises particularly doubts about whether the March 2001 legislation was adequate to face future monetary issues, as the need for financial stability appears to have been underestimated.

Other studies attempt to quantify the effect of a monetary policy shock on Norwegian stock prices. One of these is a Norges Bank staff memo report examining the distributional effects of monetary policy utilizing quarterly data from 1993 to 2015 (Mimir et al., 2021). According to the study, a 1 percent change in the nominal policy rate causes an average deviation of 2.27 percent from the steady-state level of stock prices the first year after the shock is evoked. In comparison, Bjørnland (2008) observes a relatively large impact of a 5 to 6 percent decrease in stock prices after a one-percentage-point increase in the interest rate at the beginning of the inflation-targeting period from 2001 to 2004. The methodology utilized is an event study, allowing the analysis to assess the impact of unanticipated interest rate decisions. The study confirms a simultaneous response of asset prices to monetary policy shocks. Furthermore, Bjørnland (2009) observes the effect of monetary policy on stock prices in a study evaluating the impact of oil price shocks on stock market booms in Norway from 1990 to 2005 using a structural vector autoregressive model. The study concludes that monetary policy is a short-term driver of stock price volatility, as it explains 30 percent of stock price variation within six months.

Finally, a study of ten European nations examines the relationship between stock prices and macroeconomic variables from 1968 to 1984 (Asprem, 1989). The findings indicate that the effect of an interest rate change on stock prices in Norway is minor compared to other nations. This could be attributed to illiquid financial markets, and highly regulated credit flows during the study period (Asprem, 1989). In addition, the study discovers that stock prices rise when an increase in activity is anticipated.

5 Collection and Processing of Data

The data in the analysis is chosen based on the literature review on SVAR, as well as established macroeconomic theory. This chapter elaborates on data collection and processing to assure validity and reliability. To assure consistency, all data series contain monthly observations. In particular, we present a detailed explanation of the Hodrick-Prescott filter, as this is our primary data processing approach utilized to assure stationarity in section 6.4.1 on Stationarity. Table 5.1 summarizes the sources of the data, as well as their abbreviations frequently used in this paper.

Table 5.1: Central data sources

Variable name	Description	Source
Stock prices	BXLT Linked benchmark index	Oslo Børs and Euronext
Output	Interpolated mainland GDP	SSB
Inflation	CPI Index	SSB
Oil price	Europe Brent spot price	EIA
Exchange rate	Trade weighted exchange rate index	Norges Bank
Nibor	Three-month Nibor	Norges Bank and SSB
Key policy interest rate	Sight deposit rate	Norges Bank

Stock prices

In September 2001, Oslo Børs changed its official index, and the total index (TOTX) was replaced by the Benchmark index (OSEBX). Oslo Børs established a linked version of OSEBX, the linked benchmark index (BXLT), to connect the two indices. The values in this index are adjusted using an adjustment factor based on the ratio between TOTX and OSEBX per 31. August 2001. We have retrieved the linked index from Oslo Børs[1] spanning 1990 to 2018, while the data after this period is obtained from Euronext. The daily notations are then converted into monthly averages. Since its inception in 2001, the OSEBX has contained between 52 and 81 stocks (Nordnet, 2020). As of March 2022, the index consists of 69 stocks that comprise a representative sample of all Oslo Børs-listed shares (Euronext, 2022).

[1]After the data was obtained from Oslo Børs' official website, Oslo Børs' website became part of Euronext's.

Output

Since the Norwegian economy is highly dependent on the oil and gas industry, we utilize mainland GDP to minimize the effects of petroleum activities and ocean transport. Quarterly data is downloaded from SSB, consistent with revised estimates of GDP for Norway (Grytten, 2022). Moreover, it is seasonal- and inflation-adjusted to remove fluctuations occurring in the same quarter and with the same magnitude each year (SSB, 2022b). The actual pattern in economic activity is thus better reflected.

During most of the period of analysis, mainland GDP data is only reported quarterly. In achieving consistency, the Denton method is applied. The method was initially proposed by Denton (1971) and is referred to as "an acceptable alternative" by the European Statistical System (Eurostat, 2018). When utilizing this method, we are able to interpolate the quarterly mainland GDP data to monthly. As industrial production (IP) is measured monthly and readily available at SSB, we use it as an indicator series, contributing with its pattern to the interpolation of the mainland GDP series. The monthly observations are thus consistent with the quarterly totals of mainland GDP, while the month-to-month changes relate to industrial production changes. Since IP only accounts for parts of aggregate economic activity, prior research indicates caution about using industrial production as a complete indicator for economic activity (Balke and Wynne, 1993). Hence, we utilize mainland GDP interpolated monthly instead of industrial production.

Inflation

SSB provides the Norwegian consumer price index, consistent with the revised consumer price index in Norway (Grytten, 2020a). As previously stated, the core inflation target is CPI-ATE, which is preferred utilized. However, the index has only been in place since December 2003. We, therefore, considered using the CPI-AE instead to expand the time period. This is one of the two primary components of the CPI-ATE, for which SSB holds monthly data from 1995. However, because the period of analysis begins in 1990, we utilize the broad CPI. This option is discussed more in section 5.1 on Reliability and Validity.

Oil price

The oil price is obtained from the US Energy Information Administration (EIA). Various petroleum products are traded on the world's commodity exchanges, and their prices vary due to differences in quality and transportation. However, there is a considerable degree of covariation in the price movements of the various products. Studies have demonstrated no significant differences when using different oil prices to predict stock prices (Driesprong et al., 2008). Due to the availability of data and the fact that Brent crude is the most commonly used crude oil, we obtain the Europe Brent spot price of oil in USD.

Exchange rate

Norges Bank provides the trade-weighted exchange rate index (TWI), a multilateral index. It is based on the NOK exchange rate against the currencies of Norway's 25 most important trading partners. The index is compiled as a geometric average of the exchange rates employing OECD's trade weights (Norges Bank, 2020b). As the index incorporates Norway's main trading partners, it is considered a comprehensive index following the exchange rate's position in the transmission mechanism.

Nibor

The three-month Nibor from 1990 to 2013 is downloaded as monthly averages from Norges Bank, while data from 2014 until the present is downloaded from SSB. From section 3.2 on Nibor, it follows that the 3m Nibor can be broken down into the three months expected key policy rate and a risk premium. In general, Nibor follows the key policy interest rate. However, because Norges Bank cannot directly influence the risk premium, the two variables may not always coincide perfectly.

Key policy interest rate[2]

Norges Bank's overnight lending rate, the D-loan rate, was the key policy rate until May 1993. Since then, the sight deposit rate has been employed (Norges Bank, 2015). To obtain the key policy interest rate from 1990 until today, we have retrieved daily data on the D-loan rate and the deposit rate from Norges Bank. We have further spliced the two series based on their relative relationship and converted the daily data to monthly averages.

[2]Not included in the baseline analysis, but as a variable in the robustness test.

5.1 Reliability and Validity

When ascertaining the quality of the research design, two main factors should be considered: reliability and validity of the data.

Reliability is concerned with the extent to which a measurement of a phenomenon provides steady and consistent results, as well as repeatability (Wilson, 2014). Put differently; the reliability is contingent upon both replication and consistency. The data applied in our analysis are described in detail and are readily accessible from the sources so that others, in principle, can review the evidence. In addition, we have explained the methods utilized to process the data to ensure transparency and consistency. Finally, the data are generated by reliable institutions, such as SSB and Norges Bank, indicating that they are highly reliable. However, the reliability is insufficient unless combined with validity (Wilson, 2014).

Validity refers to whether the data measure what they intend to measure (Wilson, 2014), i.e., it pertains to the data's quality and precision. Validity can be viewed based on internal and external validity. Internal validity refers to the extent to which an instrument measures what it is intended to measure, whereas external validity concerns whether the results can be generalized to other populations or settings beyond the analysis sample (Wilson, 2014).

The data collected and utilized in our analysis are carefully selected based on pertinent literature and theory. In addition, the data generally measure what they intend to measure. Frequently, data is updated or revised shortly after publication. Since our analysis utilizes data spanning 1991 to mid-2019, it excludes data from 2019 to the present. Consequently, it is less likely that the data will be updated or revised after this analysis is conducted, implying that the internal validity holds. Additionally, Grytten (2022, 2020a) has revised the time series of Norway's economic growth and consumer price index from 1816 to 2019 and 1492 to 2018, respectively. The studies find no evidence that the GDP or CPI series published from 1990 to the present should be revised since the new estimated series corresponds almost exactly with this period's previously published time series.

However, a potential threat to internal validity could be that we employ CPI rather than CPI-ATE, the inflation on which Norges Bank sets its policy. Although the CPI is more volatile since it incorporates transient changes, the two variables appear to be moving in the same direction (Jonassen and Nordbæ, 2006). Hence, we argue that this is unlikely to impact our result's validity significantly. Nonetheless, caution should be taken when interpreting the impact of monetary policy on inflation in our findings. Another possible threat to internal validity could be utilizing Nibor to determine the monetary policy shock in our analysis. Nibor is constructed based on the average estimates of six banks. This could open for banks colluding to manipulate the rate, as seen in the Libor Scandal of 2012 (Hou and Skeie, 2014). According to Finanstilsynet, however, there is no evidence that this is the case with Nibor (Finanstilsynet, 2019). In addition, our robustness test in section 7.3 verifies that the findings are nearly identical whether Nibor or the key policy rate is utilized in the regression.

There may be scenarios posing a threat to external validity. Although the effect may be comparable in other small open economies, it is dependent on the degree of financial openness of the country (Li et al., 2010). Moreover, Norwegian stocks are especially susceptible to oil price fluctuations compared to other nations. Hence, applying general inference across countries should be undertaken with caution. In addition, there have been shifts in the Norwegian monetary policy regime over the past three decades, indicating that a change in the time period may yield different results.

5.2 Hodrick-Prescott Filter

Economic parameters are unlikely to grow at the same rate year by year. Therefore, assuming a polynomial rather than a linear trend is preferable when estimating the business cycle. Since the Hodrick-Prescott filter proposed by Hodrick and Prescott (1997) is based on a polynomial trend, it is one of the most extensively used methods for determining the business cycle. We follow the explanation of Grytten and Koilo (2019) when describing the filter. The HP-filter splits the time series into a trend (g_t) and cyclic component (c_t). Accordingly, the time series (x_t) is denoted as:

$$x_t = g_t + c_t \tag{5.1}$$

where the trend component is determined by:

$$\min_{g_t} \sum_{t=1}^{T} (x_t - g_t)^2 + \lambda \sum_{t=2}^{T} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \tag{5.2}$$

Lambda (λ) is a smoothing parameter, and T is the number of observations. The filter derives the trend by minimizing variances of the cyclic component, subject to responds for second difference variation of the trend (Grytten and Koilo, 2019). Two expressions make up equation 5.2. The first expression is the time series in period t minus the trend component in period t, which equals the cyclic component. On the other hand, the second expression represents the trend's growth rate between t and t + 1.

The solution to the minimization problem is given by:

$$g = (I_n - \lambda F)^{-1} x, \tag{5.3}$$

where I_n is an n x n identity matrix and F is the penta-diagonal n x n matrix, as illustrated theoretically in equation 5.4.

$$F = \begin{pmatrix} f & 0 & 0 & & 0 & 0 & 0 \\ 0 & f & 0 & \cdots & 0 & 0 & 0 \\ 0 & 0 & f & & 0 & 0 & 0 \\ & \vdots & & \ddots & & \vdots & 0 \\ 0 & 0 & 0 & & f & 0 & 0 \\ 0 & 0 & 0 & \cdots & 0 & f & 0 \\ 0 & 0 & 0 & & 0 & 0 & f \end{pmatrix} \tag{5.4}$$

By subtracting the estimated trend component from the corresponding observed time series, the cycle components are calculated as follows:

$$c_t = x_t - g_t \tag{5.5}$$

Often it is useful to calculate relative gaps rather than absolute numbers. The parameters are therefore in logs:

$$log(c_t) = log(x_t) - log(g_t) \tag{5.6}$$

Further, when the HP-filter from equation 5.2 is applied to 5.3, the following relationship emerges:

$$\min_{g_t} \sum_{t=1}^{T} (x_t - g_t)^2 = x_t - \lambda \sum_{t=2}^{T-1} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \tag{5.7}$$

where the estimated cycle component, or residual, is:

$$\min_{g_t} \sum_{t=1}^{T} (x_t - g_t)^2 \tag{5.8}$$

When applying the equation on equation 5.6, one gets the relative deviations from the polynomial trend (Grytten and Koilo, 2019). In other words, one arrives at the relative cycles:

$$ln(c_t) = ln(x_t) - log(\lambda \sum_{t=2}^{T-1} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2) \tag{5.9}$$

Lambda specifies the relative weight denoted to the second expression in the equation and the smoothness of the estimated trend curve. If lambda is zero, the estimated trend equals the actual time series. As a result, there is no cyclic component. If lambda reaches infinity, the predicted trend is linear. None of these extreme scenarios are plausible as to why a lambda value somewhere between is adequate.

One of the challenges in determining the value of lambda is the lack of an objectively correct value (Grytten and Hunnes, 2016). In the US, it is common to choose 1,600 for quarterly data, which aligns with the value initially proposed by Hodrick and Prescott (1997). Furthermore, the volatility and frequency of the data series determine the appropriate lambda value. Ravn and Uhlig (2002) calculate that the quarterly lambda value of 1600 corresponds to a lambda value of 6.25 for annual data and 129,600 for monthly data. Other studies look into whether similar values may be transferred to other countries. For instance, according to a study from 2004 of OECD countries, the quarterly lambda value of 1600 is adequate for most countries, albeit one should not uncritically set the same value (Marcet and Ravn, 2004).

Since the HP-filter estimates the change in the trend's growth between the period t and t + 1, there is only one direction to estimate the trend at the endpoints of a time series. While at the beginning of a time series, there is no period t - 1, there is correspondingly no period t + 1 at the end. The trend estimate is thus imprecise at the beginning and the end of a time series, referred to as the "end-of-sample problem." To address this problem, it is common to eliminate the first and last 12 estimated cyclic components in a time series (Sørensen and Whitta-Jacobsen, 2010). Another approach is to expand the time series by including, for instance, more data than the period of analysis (Bjørnland and Thorsrud, 2015). Finally, one can address the problem by choosing higher lambda values.

6 Methodology

Building on the approaches of Neri (2004) and Bjørnland (2009), we present the framework of the structural vector autoregression to examine the effect of monetary policy on Norwegian stock prices. Since our identification builds on strong assumptions, we carefully explain the variables included and their ordering, while referring to economic theory and literature.

6.1 Choice of Identification Approach

Sims (1980) presented the SVAR model in the early 1980s, and it has since been widely applied in macroeconomic research (Bjørnland and Thorsrud, 2015). Few macroeconomic contributions have had a more significant impact than SVAR approaches, which earned Sims and Sargent the 2011 Nobel Prize in Economics. The approach is especially beneficial for assessing monetary policy shocks since it allows the variables of interest to be interconnected and infer economic meaning to structural shocks. Consequently, a growing body of research evaluates the monetary policy transmission mechanism using SVAR rather than VAR (Bjørnland and Thorsrud, 2015).

To determine how a monetary policy shock affects stock prices, we include variables from the monetary policy transmission mechanism in our analysis. However, the variables are parts of the same system and respond to each other with a time lag. Put differently; they can affect each other and be affected by one another, resulting in multiple directions of causality. For instance, if the output gap is positive, the central bank may respond by raising the interest rate, thereby reducing the output gap. At the same time, monetary policy can affect stock prices, and stock prices can impact monetary policy actions. Using a SVAR method that treats all variables as jointly endogenous, it is possible to solve such simultaneous problems. Each variable is allowed to depend on its past realizations and the past realizations of other variables in the system (Enders, 2015). Consequently, our empirical analysis employs a SVAR model, consistent with our research question and past research.

6.2 Choice of Variables and Time Period

Following chapter 5 on Collection and Processing of Data, the variables employed in the analysis are the nominal oil price[3], nominal stock prices[4], inflation, output, exchange rate, and Nibor. The oil price, stock prices, output, inflation, and exchange rate are all expressed in log levels. Since Nibor is already measured as a ratio, it is expressed in level. Although the primary objective of the analysis is to examine the impact of monetary policy shocks on Norwegian stock prices, we also include inflation and output as Norges Bank reacts principally to changes in these variables. Moreover, the exchange rate is included since it plays an essential role in the monetary policy transmission mechanism due to Norway's position as a small open economy. In addition, it can aid in avoiding the prize puzzle phenomenon observed in inflation after a monetary policy shock (Neri, 2004). Finally, the oil price is included due to its great impact on the Norwegian stock market.

Several other factors, such as foreign monetary policy, influence stock prices. However, SVAR models are easily heavily parameterized, consuming degrees of freedom (Bjørnland and Thorsrud, 2015). If too many variables are included, there may be too many parameters to estimate relative to the number of data observations. As a result, we choose not to include the foreign interest rate. In addition, Norway's key policy rate cannot deviate that vastly from foreign interest rates (Bache, 2018). For instance, if Norway has a higher interest rate than other countries, the appreciation of the Norwegian currency, followed by lower prices on imported goods, could decrease inflation. However, excluding foreign interest rates and additional variables impacting stock prices requires caution when interpreting the impulse response function and variance decomposition. Section 7.4 on Shortcomings elaborates further on this.

The time series are obtained from 1990 to mid-2020. To prevent the "end-of-sample-problem" caused by the HP-filter, we eliminate the first and last 12 estimated cyclic components in the time series, as suggested by Sørensen and Whitta-Jacobsen (2010). As a result, the analysis spans January 1991 to June 2019.

[3] Bjørnland's results are independent of whether using the nominal or the real oil price (2009).

[4] The estimated cycles are nearly identical when applying the HP-filter, whether using the nominal or real stock prices.

6.3 Model Specification

Following the vast majority of vector autoregression literature (Lanne et al., 2017), this analysis imposes restrictions on the contemporaneous (short-run) relations between the variables. Accordingly, the long-run behavior of the variables is left totally unrestricted. We build on Neri´s approach (2004), assuming that a structural dynamic vector equation describes the Norwegian economy:

$$A(L)y_t + c = v_t \tag{6.1}$$

where:

y_t = vector of N economic variables
v_t = vector of structural shocks
c = vector of constant
$A(L)$ is given by:

$$A(L) = A_0 - A_1L - A_2L^2 - ... - A_pL^p \tag{6.2}$$

where:

L= the lag operator
A_i $(i = 0, p)$ = NxN matrices

The following system of equations describes the reduced form of the VAR:

$$y_t = c + B(L)y_t + u_t \tag{6.3}$$

where $B(L)$ is:

$$B(L) = B_1L + B_2L^2 + ... + B_pL^p \tag{6.4}$$

u is the vector of residuals. These relates to the structural shocks by the following equation:

$$u_t = A_0^- 1v_t \tag{6.5}$$

The six variables in our analysis are included in the vector y_t. These are oil price (op), inflation (π), output (x), short-term interest rate (i) exchange rate (e) and stock prices (sp). The coefficients that link the variables, Matrix A_0, are identified through the well-known Cholesky decomposition. By utilizing the Cholesky decomposition, the reduced form variance covariance matrix of the residuals is orthogonalized (Neri, 2004). Hence, one can recover the structural shocks from this covariance when the variables are ordered recursively, as depicted in matrix 6.6. The identification implies that an ordering of the variables is chosen to only allow for contemporaneous correlations between certain series. Whereas the variable ordered on top reacts only to its own shock, the variable ordered last reacts to all shocks (Bjørnland and Thorsrud, 2015).

The variables in our analysis are ordered based on the transmission mechanism of the monetary policy, as depicted in matrix 6.6. This ordering is comparable to the one conducted by Bjørnland (2009) for the Norwegian economy.

$$\begin{bmatrix} v_{op} \\ v_x \\ v_\pi \\ v_i \\ v_e \\ v_{sp} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{bmatrix} \begin{bmatrix} u_{op} \\ u_x \\ u_\pi \\ u_i \\ u_e \\ u_{sp} \end{bmatrix} \tag{6.6}$$

The matrix implies that we assume the following restrictions on the variables:

- Only shocks to the oil price (u_{op}) can affect oil price contemporaneously
- Only shocks to the oil price and output (u_x) can affect output contemporaneously
- Only shocks to the oil price, output, and inflation (u_π) can affect inflation contemporaneously
- Only shocks to the oil price, output, inflation, and Nibor (u_i) can affect Nibor contemporaneously
- Only shocks to the oil price, output, inflation, Nibor, and exchange rate (u_e) can

affect the exchange rate contemporaneously

- All shocks can affect the stock prices contemporaneously

The oil price is placed at the top in the ordering, reflecting that exogenous oil price shocks only affect the oil price contemporaneously. Output is placed next, followed by inflation. The next variable is Nibor. Placing the monetary policy below the monetary policy target variables corresponds to the implications of an inflation targeting regime. That is, monetary policy can react immediately if output deviates from potential output or if inflation deviates from the 2 percent target. Simultaneously it takes at least one period (month) before these two variables can be affected by the monetary policy. This is a plausible assumption as Norges Bank expects its policy to impact the economy within a medium-term horizon and not immediately. The next variable is the exchange rate, implying that the Norwegian krone can appreciate or depreciate on impact in response to a monetary policy shock. Finally, the stock price is ordered at the bottom. The stock price is left completely unrestricted when placed last, assuming that all other variables can impact it contemporaneously. Particularly, ordering the stock price below the interest rate suggests that stock prices can respond immediately to changes in monetary policy.

Since the exchange rate is ordered above stock prices, it cannot respond immediately to shocks in stock prices (u_{sp}). This may be a relatively strong assumption. Hence, we reorder stock prices and exchange rate in a robustness test in section 7.3 on Robustness of Results. Moreover, since the interest rate is ordered above stock prices and exchange rate, it is restricted from reacting immediately to these variables. Bjørnland (2008) emphasizes that this may bias the impact of a monetary policy shock. However, by employing monthly instead of quarterly data, monetary policy is allowed to react faster. Consequently, we utilize monthly data, in line with Bjørnland (2009).

6.4 Assumptions

6.4.1 Stationarity

When a time series is non-stationary, regression analysis might induce spurious regressions (Bjørnland and Thorsrud, 2015). Therefore, one must ensure that the time series are stationary. Studies utilizing time series for macroeconomic purposes frequently take the first difference of the time series to obtain stationary data. However, even if a time series expands, such an approach could produce a negative number. Therefore, we employ the HP-filter to eliminate the trend from the data and make the time series stationary.

Since the applied data are monthly, the lambda value of 129 600 is selected as proposed by Uhlig and Ravn (2002). Each time series is then subject to an Augmented Dickey-Fuller test to determine its stationarity. The test confirms that all of the series, except stock prices, are stationary, as one can reject the null hypothesis of a unit root at a 5 percent level. To be able to reject the null hypothesis for stock prices, the lambda value is reduced to 110.000. The estimated trend is thus less smooth and the estimated cycle less volatile. As a result, we can reject the null hypothesis at a 5 percent level and confirm that all series are stationary. Figure 6.1 depicts the estimated cycle of stock prices graphically.

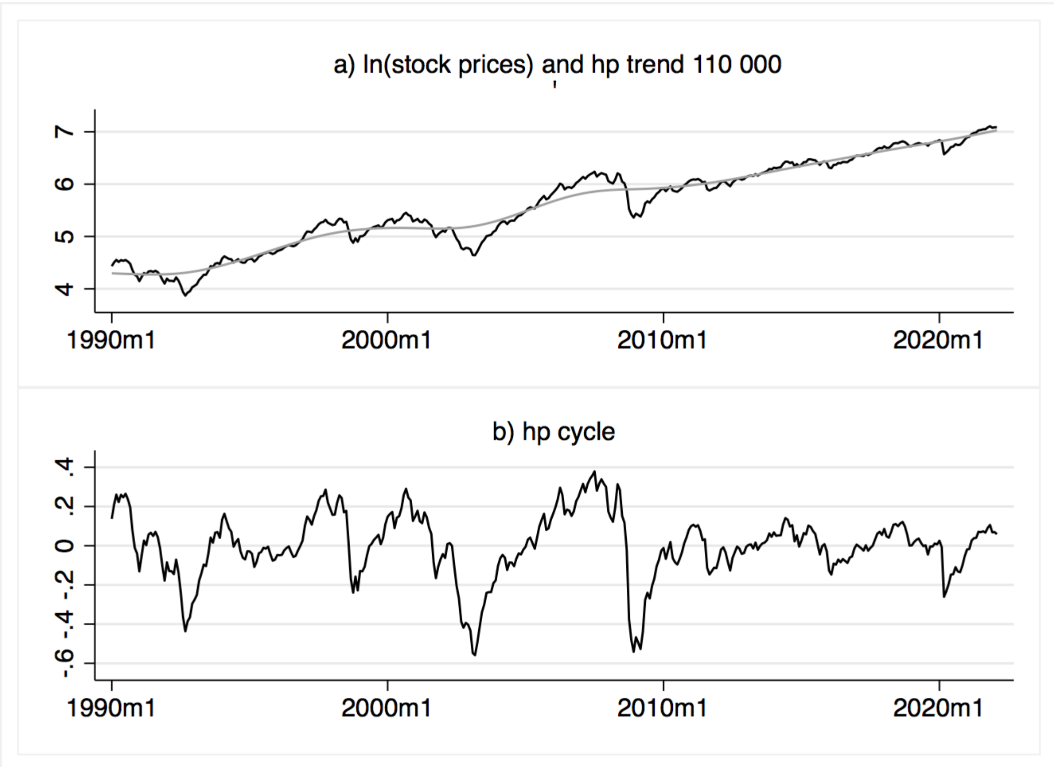

Figure 6.1: The estimated a) trend and b) cycle of Norwegian stock prices in log utilizing HP-filter with a lambda value of 110.000. Source: Oslo Børs.

Figure 6.1 a) illustrates the development of stock prices during the period of analysis and the estimated trend using the HP-filter. Figure 6.1 b) depicts the estimated cycle employed in our research. As previously stated, the HP-filter causes an "end-of-sample problem". Accordingly, we eliminate the first and last 12 months of data from the time series to avoid imprecise estimates at the beginning and the end of the estimated cycle.

6.4.2 Choice of Lags, Autocorrelation and Stability

Determining the proper lag lengths is essential when utilizing SVAR (Bjørnland and Thorsrud, 2015). A model with an insufficient number of lags may omit important information and generate autocorrelated residuals. Too many lags, on the other hand, may increase estimation errors in the model since more coefficients are estimated than necessary (Bjørnland and Thorsrud, 2015). Using formalized information criterion functions, we determine the optimal lag length. The FPE, AIC, and HQIC criteria suggest two lags, whereas the SBIC criterion only suggests one. However, utilizing a model with one or two lags results in autocorrelation in the residuals. In addition, a lag duration that is too short may omit important dynamics. The Lagrange multiplier test indicates no autocorrelation in the SVAR residuals when four lags are applied. Hence, we employ four lags. Moreover, the eigenvalues lie inside the unit cycle, indicating that the model satisfies the stability condition, i.e., it is stable. These outcomes are included in the paper's Appendix.

7 Results and Discussion

To answer our research questions, we examine two SVAR models spanning two different time intervals. The baseline model covers 1991 to mid-2019. This model analyzes the impact of expansionary monetary policy on Norwegian stock prices over the past three decades. Using impulse response functions (IRFs) and variance decomposition (FEVD), we outline and examine the transmission mechanism's variables. The second model studies the period from mid-2009 to mid-2019 through IRFs. This model attempts to observe the impact of expansionary monetary policy on stock prices over the past decade, when interest rates are historically low. Thereafter, we conduct robustness tests on the findings of the baseline model to determine the credibility and validity of the results. Finally, the chapter elaborates on the shortcomings of our analysis.

7.1 Baseline Model of 1991 to Mid-2019

When analyzing the impact of an expansionary policy on Norwegian stock prices and the economy, we discuss our findings in the context of theory and existing literature. Since the literature spans various time periods and countries, caution should be taken when comparing results. However, the literature provides a solid foundation for discussing the expected relationship between the variables and whether our overall results are small or large, unexpected or not.

7.1.1 The Impulse Response Function

This section examines the impulse response function. The function describes shock affects the current and future values of a variable in the y_t-vector, holding other shocks constant. While the impulse can be seen as the cause, its propagation is the effect over time (Bjørnland and Thorsrud, 2015). Since the impulse response functions are constructed using estimated, imprecise coefficients, the impulse responses contain errors (Enders, 2015). Therefore, confidence intervals are constructed to allow for the parameter uncertainty inherent in the estimation process. As suggested by Sims and Zha (1999) for SVAR analysis, the confidence interval is set to 68 percent.

Since our research question concerns the impact of monetary policy on stock prices, we first analyze the response of a shock in Nibor on stock prices. Then, we examine how a change in Nibor affects the other variables to determine if our model aligns with the channels of the monetary policy transmission mechanisms. As depicted on the horizontal axes of the impulse responses in figure 7.1, the estimated responses are presented over a 24-month forecast horizon. When referring to a monetary policy shock, we define it as a change of 100 basis points or 1 percent in Nibor. The vertical axes represent the percentage response of a monetary policy shock as a decimal. For instance, 0.01 in the axes reflects a response of 1 percent. The impulse response functions illustrate how an increase in Nibor impacts the economy. Furthermore, all graphs depict the responses to a contractionary monetary policy shock.

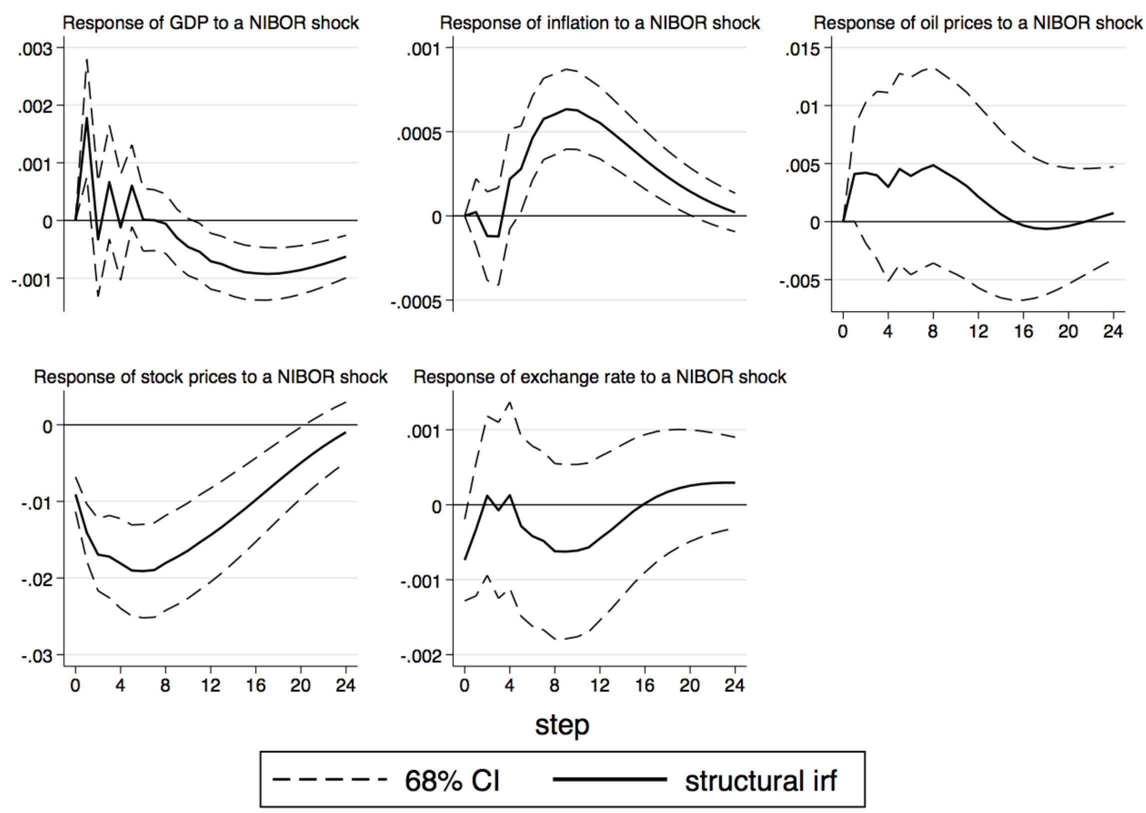

Figure 7.1: Impulse responses with probability bands of the baseline model of 1991 to mid-2019. Response in output, inflation, oil price, stock prices, and exchange rate to a Nibor shock. x-axes: months. y-axes: percentage as a decimal.

In line with theory and empirical findings, the results demonstrate that a contractionary monetary policy shock decreases stock prices. Put another way; expansionary monetary policy increases stock prices. When utilizing a 68 percent confidence interval, the effect is significant over a 20-month horizon. However, the immediate effect is relatively small compared to the effect after a few months. Following the initial expansionary monetary policy shock, stock prices rise by 1 percent on impact, ascending for six consecutive months. They then reach the peak at slightly below 2 percent before returning to their average level after 24 months.

Assuming a one-to-one relationship between a change in nominal and real interest rates, the DCF-model could explain the rise in stock prices (Møller and Kaldestad, 2016). A lower key policy interest rate may lead to a lower discount rate, raising the stock prices if a higher risk premium does not outweigh this effect. Concurrently, a drop in interest rates could signal to investors that economic activity is projected to increase. This may raise the firm's estimated future earnings and expected cash flows, increasing the stock price. Furthermore, as Tobin (1965) and Mundell (1963) propose, households may shift their savings from bank accounts to assets in demand for a higher return when interests are low, causing stock prices to rise.

Compared to international SVAR literature, our findings tie well to the study by Neri (2004) for the G7 countries. The analysis discovers that the maximum response of a 100 basis points increase in the interest rate on stock prices is between 0.1 and 6 percent and is reached within 2 to 12 months. Although the outcomes are comparable, the impact of a monetary policy shock on stock prices in Norway lies in the lower range. One possible explanation could be that the Norwegian stock market is strongly affected by oil price volatility due to Norway's position as an oil nation. Therefore, compared to other non-oil exporting economies, Norway's monetary policy may have a relatively smaller effect on the stock market.

In addition, our findings are significantly smaller compared with the conclusions from studies regarding the US economy (Bjørnland and Leitemo, 2009; Li et al., 2010). Li et al. (2010) emphasize that the impact of a domestic monetary policy shock is considerably smaller in Canada, a small open economy, than in the US, a large closed economy. Similar to Canada, Norway is a small open economy. Accordingly, the Norwegian stock market is heavily influenced by external factors such as the foreign interest rate. This may justify why the effect of a domestic monetary policy shock in Norway is considerably smaller than in the US. In addition, Bjørnland and Leitemo (2009) employ both short-run and long-run restrictions when identifying a larger effect than most other VAR studies. Consequently, applying solely short-run restrictions to our model may contribute to our minor findings.

Regarding previous findings on the impact of monetary policy on Norwegian stock prices, our results are broadly in line with those of Mimir et al. (2021) spanning the period from 1993 to 2015. The study observes that monetary policy shock causes an average deviation of 2.27 percent from the steady-state level of stock prices in the first year after the shock is evoked. In comparison, Bjørnland (2008) observes a relatively large impact on stock prices when examining part of the inflation-targeting period from 2001 to 2004 in Norway. Specifically, the event study reveals that stock prices decrease immediately by 5 to 6 percent following a one-percentage-point unanticipated interest rate increase. However, since our analysis does not differentiate between anticipated and unanticipated changes in the interest rate, our result may be minor. According to the efficient market hypothesis, changes should already be reflected in the stock market prior to an anticipated change in interest rates. Consequently, it is likely that our model cannot capture the full immediate impact. This is plausible as our analysis employs a time period characterized by a more transparent monetary policy (Grytten et al., 2021). Therefore, the market could anticipate the future direction of the interest rate and adjust before the central bank implements a policy change. We will, however, revisit this when reviewing our findings from the SVAR model spanning mid-2009 to mid-2019 in section 7.2.

Furthermore, the impact of a monetary policy shock on other variables is examined, as depicted in figure 7.1. The output increases before gradually declining in response to a contractionary monetary policy. Put differently; following an expansionary monetary policy, the output falls on impact and increases within a few months. The initial decrease contradicts the monetary policy transmission mechanism. According to the mechanism, a reduction in interest rates increases demand for goods and services. In addition, investment projects turn more profitable, which increases the level of economic activity and the output (Røisland and Sveen, 2018). However, unlike monetary policy transmission to stock prices, monetary policy transmission to output takes longer. Since 2005, Norges Banks' target has been a medium-term target, suggesting that they expect the policy to work on the real economy within a medium time horizon (Grytten et al., 2021). In line with Norges Banks' target and the transmission mechanism, the output increases within a short time period. The increase is significant at a 68 percent confidence interval, suggesting the expansionary monetary policy stimulates increased economic activity with a time lag.

Despite not being statistically significant, the exchange rate depreciates on impact following an expansionary monetary policy shock, in line with the assumption that UIP holds (Røisland and Sveen, 2018). The oil price decreases following an expansionary monetary policy shock. However, the impact is neither significant at the 68 percent nor the 95 percent confidence interval, indicating that monetary policy is unlikely to impact the oil price.

Contrary to what economic theory would predict, inflation first decreases due to a decrease in the interest rate. The initial decrease in inflation is referred to as a price puzzle and exists in previous VAR literateur (Bjørnland and Leitemo, 2009). Although our analysis includes the exchange rate, which could aid in avoiding the price puzzle, it fails to do so. In addition, the magnitude of the price puzzle effects may be explained by our use of the broad CPI-index, which is more volatile than the CPI-ATE index (Jonassen and Nordbæ, 2006). The effect on inflation is significant, but its significance and effect diminish over time. Following an expansionary monetary policy, inflation starts increasing gradually after eight months, so the medium-term effect is consistent with an expansionary monetary policy that aims to increase inflation and economic activity.

Our findings are plausible and somewhat in line with expectations, but negligible. However, the evidence from the impulse response functions should not be overinterpreted. This is partly due to the possibility of omitted variables in our analysis, as discussed in section 7.4 on Shortcomings.

7.1.2 Decomposition of Variance

By utilizing forecast error variance decomposition, one analyzes the contribution of variables to fluctuations in stock prices. This serves as a substantiating method for evaluating the effects of monetary policy shocks on stock prices, as it makes more sense to describe the effects of a monetary policy shock if it explains a portion of the variance of the variables of interest (Bjørnland and Thorsrud, 2015). In particular, we emphasize how the impact of shocks differ in terms of immediate and short-medium time horizons. The horizontal axes of the figures in figure 7.2 represent months, whereas the vertical axes represent each variable's contribution to the fluctuations in stock prices. For instance, 0.1

suggests a contribution of 10 percent.

On impact, monetary policy shocks account for a negligible portion of the variation in stock prices, as depicted to the left side in figure 7.2. However, the contribution increases over time. It accounts for 10 percent of the variance after six months, before peaking at slightly below 20 percent after two years. These findings differ in magnitude and persistency compared with international and Norwegian studies. For instance, Rapach (2001) discovers that monetary policy explains 30 percent of the variance in stock prices in the US after a year. Bjørnland (2009) also discovers a 30 percent contribution in stock price variance in Norway, but the effect is more temporary lasting only six months before diminishing.

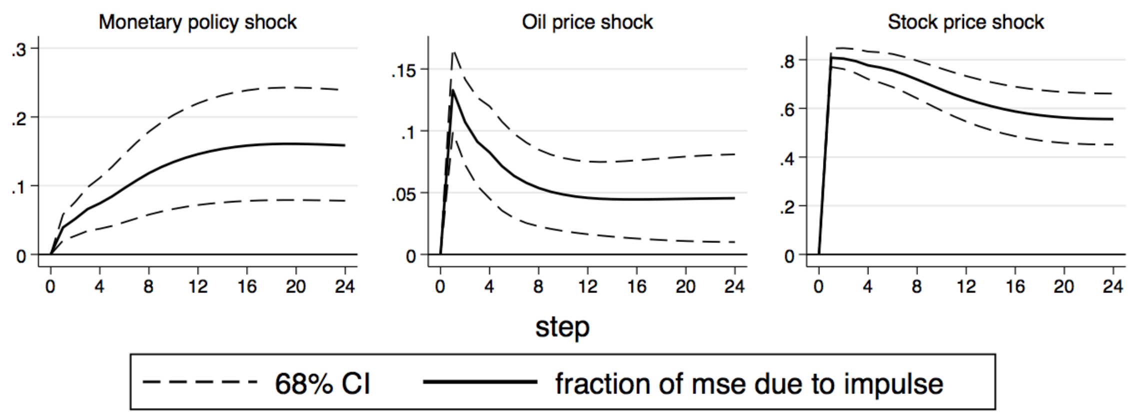

Figure 7.2: Forward error variance decomposition of the baseline model of 1991 to mid-2019. Contribution of a monetary policy shock, oil price shock and stock price shock to fluctuations in stock prices. x-axes: months. y-axes: proportion.

As expected, a shock to the stock price itself explains most of the immediate variance in stock price, making up 80 percent of the total contribution. However, it explains smaller proportions of the forecast error variance at longer horizons, consistent with typical results in applied research (Enders, 2015). Aside from the stock price shock itself, a shock to the oil price provides the most considerable immediate fraction of variance in stock prices, at nearly 15 percent. This is five percent less than the findings of Bjørnland (2009). Nevertheless, its impact is declining rapidly over time.

Although the estimated effects are relatively uncertain, the monetary policy shock appears to be a critical predictor of stock price movements.

7.2 Model of Mid-2009 to Mid-2019

As depicted in figure 7.3, short-term interest rates have declined over the past three decades, while stock prices have risen substantially. Since the financial crisis, stock prices have continued to rise while Nibor has been low with few substantial adjustments. Moreover, a correlation test reveals that the two variables provide a stronger negative correlation after 2009 than before the financial crisis. Therefore, we find it intriguing to investigate whether the recent decade's low interest rates may have contributed to the substantial increase in stock prices.

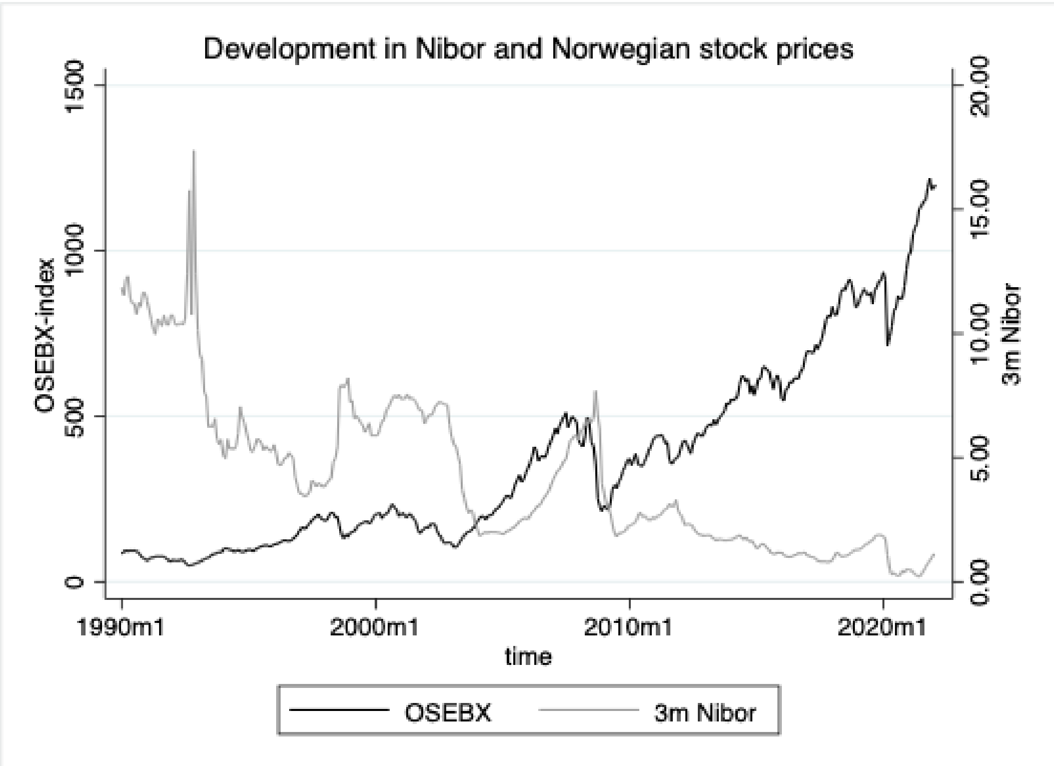

Figure 7.3: Development in Nibor and Norwegian stock prices from 1991 to 2020. Sources: Norges Bank and Oslo Børs.

We aim to observe the transmission of monetary policy through stock prices, by mainly examining the impact of a Nibor shock on stock prices. In addition, we shortly elaborate on the impact of a monetary policy shock on economic activity, as well as the impact of a stock price shock on economic activity. Accordingly, we conduct a SVAR analysis of this period. The results from this particular period are compared to the baseline model's results or the full-time horizon, as displayed in 7.4.

7.2.1 The Impulse Response Function

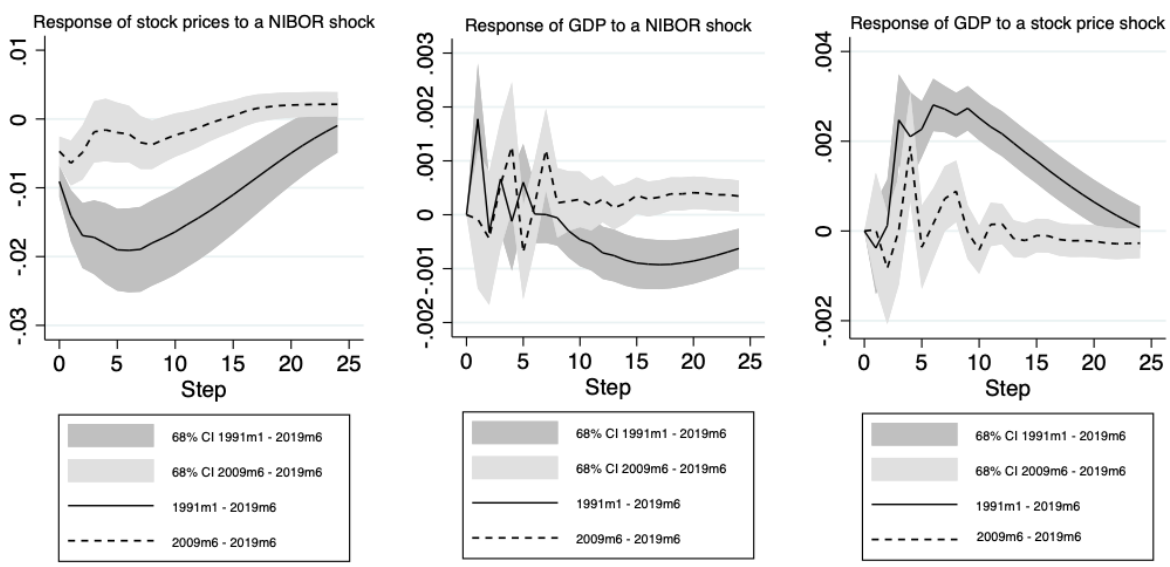

Figure 7.4: Impulse responses with probability bands of the baseline model of 1991 to mid-2019 and the model of mid-2009 to mid-2019. Response in stock prices to a Nibor shock, response in output to a Nibor shock, and response in output to a stock prices shock, respectively. x-axes: months. y-axes: percentage as a decimal.

The left side figure of figure 7.4 depicts the impact of a monetary shock on stock prices. When examining the model of mid-2009 to mid-2019, an expansionary monetary policy shock causes an immediate rise of 0.5 percent in stock prices before the effect gradually diminishes. Therefore, the effect on impact is similar to the findings in the baseline model. However, the effect in the baseline model increases for six months, reaching its peak of 2 percent. Accordingly, the transmission of the interest rate on stock prices in the post-financial crisis period is significantly weaker than in the full-time horizon. We discuss potential explanations for the negligible effect, given that the result contradicts our expectations of a larger impact.

The greater transparency of Norges Bank's monetary policy may explain why the impact is more negligible from mid-2009 to mid-2019. Although there was some transparency in the 1990s due to Norges Bank's informative publications, the interest rate path published in 2005 substantially increased transparency and openness. Norges Bank Watch puts forward that this may have contributed to lower volatility in the key policy interest rate in Norway after 2005 (Bjørnland and Wilhelmsen, 2011). Moreover, the report states that high volatility in monetary policy could increase asset price volatility. Consequently, lower key policy interest rate volatility could be associated with more stable asset prices. In addition, the increased transparency is consistent with the efficient market hypothesis explaining how new information is reflected in the market. The market is not only reacting to the policy rate set eight times a year but also to the forecast of future policy rate development announced four times a year (Norges Bank, 2022b). According to EMH, anticipated changes in the interest rate due to the announcement of the policy rate path should be reflected immediately in stock prices, hence prior to the actual key policy rate adjustment.

Moreover, the hypotheses of Mundell (1963) and Tobin (1965) may contribute to explaining the findings. When interest rates are persistently low, the alternative cost of investing in non-interest-bearing assets is reduced. Consequently, households are more likely to invest in high-return assets. Instead of responding to fluctuations in the interest rates, investors may have responded to persistently low rates. This may result in a long-term shift in saving preferences, followed by increasing stock prices over time. Such a shift is improbably captured by our model, as the model predicts short-run effects of monetary policy shocks more accurately than long-run effects.

Another effect not captured in the model is the 3m Nibor risk premium. The premium has increased in some periods following the Financial crisis, leading to an increase in Nibor (Tafjord et al., 2016). When the risk premium is high, the impact of changes in the key interest rate on market rates may be more negligible. For instance, even if the key policy rate is reduced, a large risk premium can keep Nibor at a higher level. Consequently, our model may not adequately reflect the impact of a change in the key policy rate if Nibor is not adjusting accordingly. This may partly explain why our model predicts a modest effect of a shock to Nibor on stock prices.

The diminished impact of monetary policy on stock prices may also be attributable to the greater emphasis placed on financial stability since the financial crisis (Røisland and Sveen, 2018). This implies that Norges Bank may permit a higher production or inflation gap when setting the interest rate to prevent fluctuations in financial variables. Prior to the financial crisis, the central bank set low key policy interest rates in line with a relatively strict focus on inflation targeting. This caused asset bubbles to occur (Grytten et al., 2021). Since the central now takes precautions to avoid financial instability, such bubbles may occur less frequently. Accordingly, it may be conceivable to observe a minor increase in stock prices following a key policy rate reduction.

Comparing the effect of a stock price shock on economic activity reveals another interesting finding, as depicted on the right side of figure 7.4. Consistent with the transmission mechanism through stock prices (Mishkin, 2001), the baseline model results indicate that a rise in stock prices leads to increased economic activity. The impact is significant over two years. In contrast, when examining the model from 2009 to 2019, there is no such long-lasting influence. This discovery highlights the phenomenon of historically low interest rates, modest economic growth, and higher-than-ever stock prices. Even when interest rates are low and stock prices high, economic activity does not appear to increase. This may be a result of a weakened Balance sheet channel (Mishkin, 2001) due to stricter credit policies in the aftermath of the financial crisis (Lundquist et al., 2016). Stricter credit supply regulations may reduce banks' willingness to lend since new credit standards impose stricter requirements on borrowers. Consequently, firms' investment opportunities and economic activity may be limited despite rising stock prices.

Finally, the findings provide evidence that the strength of the monetary transmission to output tends to wane when interest rates have remained low for an extended period. This is displayed in the middle of figure 7.4. In actuality, we find no significant effect, which may appear improbable. Nonetheless, a weaker effect is consistent with economic activity growth having slowed while interest rates have decreased over the past decade.

Furthermore, a weaker transmission mechanism is broadly in line with literature examining the impact of persistently low interest rates on the economy of advanced economies (Borio et al., 2021; Boucher et al., 2020).

However, the results from the model spanning mid-2009 to mid-2019 should be interpreted with caution for several reasons. Firstly, the time period studied is brief, considering the number of parameters to be estimated. Secondly, the model better predicts the effects of a monetary policy shock on stock prices in the short run than in the long run. Finally, although the model is stable and shows no evidence of autocorrelation, some of the variables are not stationary at a 5 percent level in this specific period.

7.3 Robustness of Results

To assess the robustness of our baseline model, we investigate the model's sensitivity by altering certain assumptions.

In the first robustness test, we substitute Nibor with the key policy interest rate. As with the baseline model, we conduct a Dickey-Fuller test to ensure that the time series of the key policy interest rate is stationary within a 5 percent confidence interval. The lag length is set to five [5], there is no autocorrelation, and the regression is stable. Following a decrease in the key policy interest rate, stock prices increase by 1 percent on impact, as in the baseline model. Furthermore, the peak is reached within four months and lasts twice as long as the baseline model's findings. Nevertheless, the peak occurs at 2 percent. Hence, the results do not differ substantially. The impulse response functions can be found in the paper's Appendix.

The ordering of the variables has significant implications for the variance decomposition and the impulse response function (Enders, 2015). Therefore, we reorder the stock price and the exchange rate while keeping everything else constant. By reordering the variables, the exchange rate is allowed to react immediately to all news, including stock price shocks. Examining the impact of a monetary policy shock on stock prices in a different order reveals no significant difference in the results depicted in figure 7.1. This is in line with

[5] Autocorrelation exists when selecting a lag length of four. Since the baseline model results are nearly identical whether four or five lags are pursued, we are confident that altering the lag length only has a negligible effect on the robustness test results.

the rearranging of the order by Bjørnland (2009). She emphasizes that it is unlikely that a reaction in the exchange rate to news about stock prices is not already reflected in other variables. This justifies why the results are comparable.

The two robustness tests indicate that the baseline model is relatively robust since modifications have minimal impact on the results. However, it is sensitive to time period changes, as demonstrated by the model from mid-2009 to mid-2019. Consequently, the model's results apply to the specific time period in Norway. Put differently; they cannot be generalized to be representative of other populations or settings beyond the sample under consideration.

7.4 Shortcomings

We proceed with care when extrapolating the data, despite obtaining economically viable results where the direction of the impulsive reactions coincides with economic theory. Due to model specifications, data processing and choice of variables, the findings should be interpreted with caution.

As previously discussed, the analysis does not distinguish between an anticipated and non-anticipated change in the interest rate. The key policy rate may have been adjusted in line with Norges Banks' communication of the future policy rate development, or an interest rate cut may have been unexpected. For example, Norges Bank cannot predict interest reductions prior to crises. In contrast, if the rate is expected to remain low for an extended period, investors' expectations may be altered prior to a policy rate change. In such circumstances, stock prices may already reflect the interest rate changes. Due to the difficulty in discerning the effect of an anticipated or unanticipated increase in the interest rate, the response of a monetary policy shock on stock prices may be challenging to interpret.

A further concern relates to omitted variables, specifically foreign factors impacting the monetary policy transmission mechanism due to Norway's position as a small open economy. For instance, shocks impacting Norway's trading partners also affect the Norwegian economy. Consequently, external factors significantly impact the Norwegian stock market. The impulse response is sensitive to omitted variables since these factors are present in the residuals (Bjørnland and Thorsrud, 2015). Accordingly, there might be distortions in the impulse responses, and the interpretations might be problematic. This may pose a threat to the internal sample validity. Including more foreign variables could have made it more acceptable to interpret the responses, although it is generally advisable to avoid overinterpreting the results. Regarding internal validity, it would also likely have improved our results to utilize the CPI-ATE instead of CPI, as discussed in chapter 5 on Collection and Processing of Data. Moreover, removing a trend from data generated by a random walk may induce spurious cycles (Bjørnland and Thorsrud, 2015). Hence, the time series could be treated more thoroughly based on their nature, i.e., whether they follow a deterministic or stochastic trend.

8 Further Research and Concluding Remarks

The preceding chapters have shown how monetary policy impacts the overall economy. However, to answer our research questions, the impact of monetary policy on stock prices has been the main focus. Understanding this relationship is important from both the public's and policymakers' points of view. This final chapter concludes with recommendations for future research, as well as some closing remarks.

8.1 Further Research

Due to limited literature on the topic, additional research on the effect of monetary policy on Norwegian stock prices could prove quite beneficial. Improvements for future research can be drawn from the shortcomings discussed in the previous section.

Future research should pay closer attention to the possible implications of global issues, as the transmission mechanism is heavily influenced by important trading partners and international economic shocks. As a result, we propose allowing for a more comprehensive interaction with the global economy by integrating additional foreign variables in the model. Studies may also benefit from utilizing CPI-ATE instead of CPI, particularly if evaluating data beginning in 2004, when the index first was published. In addition, we suggest research to more thoroughly base the choice of detrending on the nature of the time series. Finally, investigating the distinction between an anticipated and non-anticipated monetary policy shock might prove important in further work.

8.2 Conclusion

This study examines the effect of domestic monetary policy shocks on Norwegian stock prices from 1991 to mid-2019. Following Neri (2004) and Bjørnland (2009), a structural vector autoregression with short-run restrictions and a Cholesky decomposition is utilized. Consistent with these studies, we employ monetary transmission mechanism variables including the three-month interest rate, inflation, output, and trade-weighted exchange rate, in addition to stock prices. The oil price is also included because of its significant impact on the Norwegian stock market. In an effort to answer this study's research questions, the analysis is divided into two samples: the baseline model from 1991:M1 to 2019M6 and the post-financial crisis period from 2009:M6 to 2019M6.

The first research question is related to how expansionary monetary policy has impacted Norwegian stock prices over the past three decades. Aiming to address this question, we observe that following a 100 basis points decrease in Nibor, stock prices increase by 1 percent on impact, in line with the implications of the DCF-model. After six months the effect is 2 percent with monetary policy shocks accounting for slightly less than 10 percent of stock price fluctuations. After two years monetary policy accounts for roughly 20 percent of stock price variation. These results are relatively robust and the findings generally align with the channels of the monetary policy transmission mechanism.

Compared to existing literature, our findings indicate a weaker effect of a monetary policy shock on stock prices. One possible explanation is that the Norwegian stock market is strongly affected by oil price volatility due to Norway's position as an oil nation. Accordingly, domestic monetary policy may have a relatively limited impact on the Norwegian stock market compared to other non-oil exporting economies. Furthermore, Norway is a small open economy with a stock market heavily influenced by external factors, such as foreign monetary policy. This could explain why the impact is significantly smaller than in the US. In addition, the slight effect could be attributed to enhanced transparency and openness in the Norwegian monetary policy after 2005. When the market is semi-efficient, expected interest rate changes influence stock prices prior to an interest rate adjustment. This may also explain why our results are minor compared to Norwegian literature distinguishing between anticipated and non-anticipated interest rate changes.

The second research question concerns the impact of expansionary monetary policy on stock prices over the past decade, under persistently low interest rates. Following a 100 basis points decrease in Nibor, stock prices increase by 0.5 percent on impact. The effect gradually wanes over time. Hence, the impact of monetary policy on stock prices appears to have diminished significantly. In contrast to the baseline model, forecasts of the key policy rate have been published throughout the entire period of analysis, which could have resulted in less volatile stock prices. Moreover, the negligible effect could be explained by a broad movement in saving preferences away from bank accounts toward stocks, as proposed by Mundell (1963) and Tobin (1965). In such circumstances, investors may have reacted to persistently low rates rather than to changes in the interest rate. Such a shift is improbably captured by our model, as the model predicts short run effects of monetary policy shocks more accurately than long run effects. The diminished transmission mechanism is also supported by our findings showing that the impact of a monetary policy shock and a stock price shock on economic activity has diminished significantly. Due to the existence of non-stationary time series during this particular time period, the results of this model should be interpreted with caution.

Overall, our analysis offers updated validity to previous literature. The findings are consistent with well-established macroeconomic theories, demonstrating that expansionary monetary policy increases Norwegian stock prices. However, the effect appears to have diminished over the past decade.

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Appendix

Table A0.1: ADF Test Baseline model - Stock prices

		T-Statistic	Probability
Augmented Dickey Fuller Test		**-2.879**	**0.0478**
Test critical values	1 % level	**-3.453**	
	5 % level	**-2.876**	
	10 % level	**-2.570**	

Table A0.2: ADF Test Baseline model - Exchange rate

		T-Statistic	Probability
Augmented Dickey Fuller Test		**-3.715**	**0.0039**
Test critical values	1 % level	**-3.453**	
	5 % level	**-2.876**	
	10 % level	**-2.570**	

Table A0.3: ADF Test Baseline model - Inflation

		T-Statistic	Probability
Augmented Dickey Fuller Test		**-5.583**	**0.0000**
Test critical values	1 % level	**-3.453**	
	5 % level	**-2.876**	
	10 % level	**-2.570**	

Table A0.4: ADF Test Baseline model - Nibor

		T-Statistic	Probability
Augmented Dickey Fuller Test		**-4.877**	**0.0000**
Test critical values	1 % level	**-3.453**	
	5 % level	**-2.876**	
	10 % level	**-2.570**	

Table A0.5: ADF Test Baseline model - Oil price

		T-Statistic	Probability
Augmented Dickey Fuller Test		**-3.799**	**0.0029**
Test critical values	1 % level	**-3.453**	
	5 % level	**-2.876**	
	10 % level	**-2.570**	

Table A0.6: ADF Test Baseline model - Output

		T-Statistic	Probability
Augmented Dickey Fuller Test		**-13.823**	**0.0000**
Test critical values	1 % level	**-3.453**	
	5 % level	**-2.876**	
	10 % level	**-2.570**	

Table A0.7: Lagrange-Multiplier test for baseline model

lag	chi2	df	prob > chi2
1	**28.9516**	**36**	**0,79161**
2	**38.8872**	**36**	**0,34100**
3	**34.7762**	**36**	**0,52671**
4	**29.8203**	**36**	**0,75643**

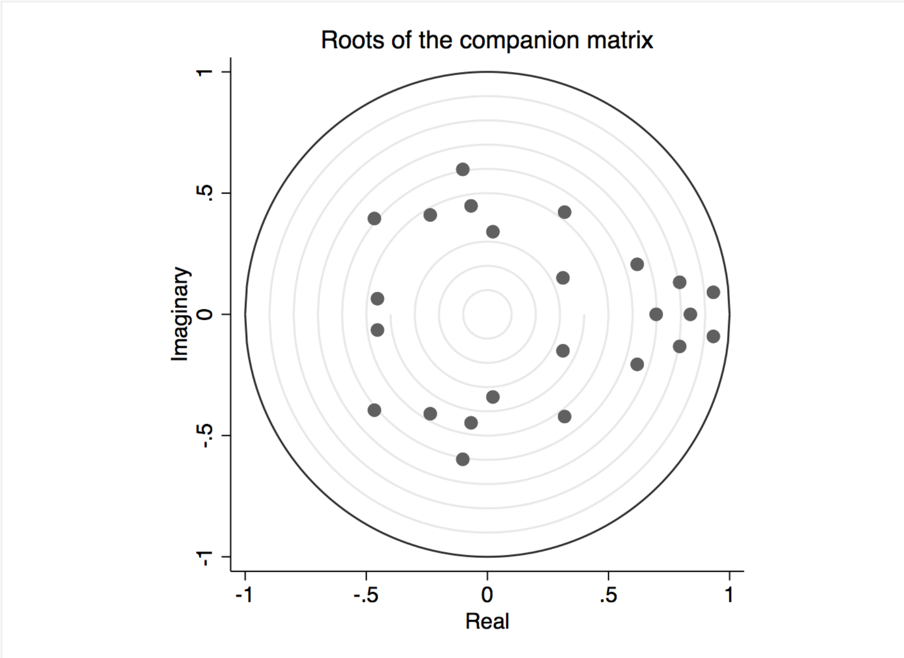
H0: No autocorrelation at lag order

Table A0.8: Choosing optimal lag length

Sample: **1991m1 - 2019m6** Number of obs = **342**

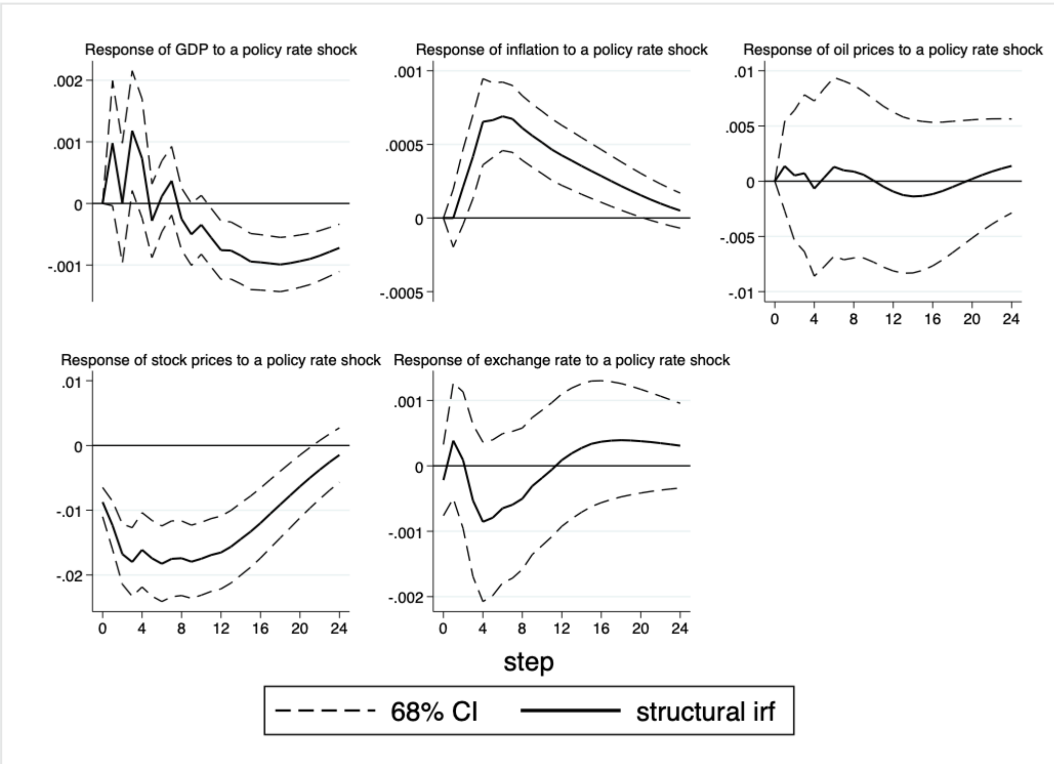
0	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	**2482.39**				**2.1e-14**	**-14.4818**	**-14.455**	**-14.4145**
1	**3950.65**	**2936.5**	**36**	**0.000**	**4.8e-18**	**-22.8576**	**-22.67**	**-22.3867***
2	**4037.58**	**173.87**	**36**	**0.000**	**3.5e-18***	**-23.1555***	**-22.807***	**-22.2809**
3	**4072.08**	**68.993**	**36**	**0.001**	**3.6e-18**	**-23.1467**	**-22.6374**	**-21.8684**
4	**4097.7**	**51.232***	**36**	**0.048**	**3.8e-18**	**-23.0859**	**-22.4159**	**-21.404**

Figure A0.1: Eigenvalue Stability Condition



All the eigenvalues lie inside the unit circle. VAR satisfies stability condition.

Figure A0.2: Robustness test 1: Substituting Nibor with the key policy interest rate



Impulse responses with probability bands of the baseline model of 1991 to mid-2019. Response in output, inflation, oil price, stock prices, and exchange rate to a key policy interest rate shock. x-axes: months. y-axes: percentage as a decimal.