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FINANCIAL STABILITY AND MONETARY POLICY – IS THERE A CONNECTION?

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Abstract

Price stability has been central banks' primary objective for decades. Before the global financial crisis, price stability was thought to be enough to safeguard both economic growth and financial stability. However, the global financial crisis showed that disruptions in the financial system could cause significant issues to the real economy and that price stability might not be enough.

This thesis studies whether central banks react to financial stability measures like asset prices or credit when setting monetary policy. An econometric study is performed on the Bank of England, Norges Bank, and Sveriges Riksbank to determine whether their monetary policy includes financial stability considerations. Additionally, a literature review is provided on the relationship between monetary policy and financial stability to lay the foundations for the estimations.

Financial stability, defined as the smooth functioning of the financial system, is an alternative goal for central banks, usually maintained with macroprudential policies. Central banks' primary goal is price stability, maintained with monetary policy. The monetary policy toolkit consists of conventional policies, such as the policy rate and open market operations, and unconventional policies, such as quantitative easing and forward guidance. The prevalent view is that monetary policy should focus on price stability and macroprudential policies on financial stability, but competing views, such as the leaning-against-the-wind policy, have been introduced.

In theoretical literature, expansionary monetary policy causes asset prices to increase, sometimes over fundamentals. Additionally, the expansionary monetary policy increases lending and leverage, enabling the buildup of financial imbalances. Relaxed monetary policy can also increase the risk-taking of both investors and banks.

The empirical literature has no consensus on the relationship between monetary policy and financial stability. Expansionary monetary policy surprises are found to increase asset prices, but the effect is minor and depends on the initial price level for property prices. Additionally, expansionary monetary policy is found to increase risk-taking.

We use the autoregressive distributed lag model (ARDL) to study an augmented Taylor rule. The monetary policy indicator is a dependent variable, with inflation, output gap, stock prices, real residential housing prices, and total credit to the non-financial private sector being explanatory variables. We find that central banks do not significantly react to financial stability measures.

Keywords
Monetary policy, financial stability, financial imbalances, autoregressive distributed lag model

Additional information

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1 INTRODUCTION

For decades, the monetary policy central banks conduct has had a clear target, price stability. In 2022, the interest rates rose at speed not seen after the global financial crisis of 2008, and the continuous policy rate increases by numerous central banks worldwide have been done to combat inflation and retain price stability. Price stability is crucial for the economy's functioning, but price stability may not always be enough. In 2008, the global economy was struck by shocks that caused financial instability, leading to a liquidity crisis and, eventually, a recession. Because of the crisis, financial stability and the role of the central bank in maintaining it came under scrutiny.

This thesis aims to study the relationship between monetary policy and financial stability by providing an econometric study. We analyse whether three European central banks, the Bank of England, Norges Bank, and Sveriges Riksbank, consider financial stability when setting monetary policy. Thus, the main research question of this thesis is *are financial stability issues considered in monetary policy?* To answer the main research question effectively, we answer two supporting questions to lay the foundations for the analysis. Supporting questions are *is there a relationship between monetary policy and financial stability?* and *how financial stability could be measured?*

Maintaining financial stability is very important, as financial instabilities become a crisis in the worst-case scenario. Financial crises cause severe and long-lasting effects on the financial system and the real economy, and thus, preventing them is very important. When the financial system is in crisis, increased adverse selection and moral hazard problems cause adverse effects in the financial system that impede the effective allocation of resources (Mishkin, 1992). A financial crisis can also be distinguished as an episode of market-wide excess volatility, illiquidity, and insolvency (Bordo et al., 2001). Thus, financial stability is a very current and essential topic, and this thesis adds to the existing literature by providing an up-to-date literature review and econometric study.

How does monetary policy fit into all this? After the global financial crisis, it has been argued that relaxed monetary policy in the years prior to the crisis caused the crisis directly or provided a suitable environment for the build-up of financial imbalances. Authors such as Claudio Borio and William White from the Bank of International Settlements (BIS) have argued for monetary policy to lean against the wind or proactively react to financial imbalances. On the other side of the spectrum, Ben Bernanke and Lars Svensson, to name a few, have argued for monetary policy to stick to price stability. To this day, no clear consensus has formed on the topic.

This thesis consists of three main parts. First, a literature review on financial stability is provided in chapter two. Topics are presented at a general level, but country-specific details are provided to enable in-depth analysis. Central banks' objectives and monetary policy tools, both conventional and unconventional, are discussed from the perspectives of price stability and financial stability. Macroprudential policies are excluded from the thesis as they are separate from monetary policy, and their objective is to maintain financial stability, thus making studying them unattractive. Also, macroprudential policies are usually managed by a separate agency from the central bank.

In addition to the monetary policy toolkit, monetary policy transmission channels are presented, as they are crucial in transmitting monetary policy into the real economy. Transmission channels also have financial stability considerations, as monetary policy affects many things, such as asset prices. In addition to the traditional channels, such as the interest rate and credit channels, monetary policy's risk-taking and signalling channels are discussed. Theoretical studies find a relationship between monetary policy and financial stability but disagree on the magnitude and direction of the effect. Empirical studies also find a connection, but again the magnitude of the effect is negligible.

Chapter three presents the traditional Taylor rule and its augmented version. Monetary policy is presented in two ways; a policy rate set by a central bank and a shadow rate considering unconventional monetary policies. In the traditional Taylor rule by Taylor (1993), the monetary policy indicator is explained by inflation and the output gap. In all three countries analyzed, inflation has been persistently low in the 21st century, excluding the extraordinary period of high inflation beginning with the Covid-19 pandemic and accelerating due to the war in Ukraine in 2022. The output gap has also remained stable in the 21st century, with the global financial crisis and the Covid-19 pandemic causing volatility.

The Taylor rule is augmented with financial measures to study the relationship between monetary policy and financial stability. In this thesis, real residential property prices, stock prices and total credit to the private sector are chosen as measures. These variables are chosen based on the existing literature on the topic and because central banks monitor these variables frequently.

Finally, chapter four estimates an econometric model based on the augmented Taylor rule presented in the second part. The model used is an autoregressive distributed lag model (ARDL). The sample estimated consists of quarterly data from 2000Q1 to 2021Q4 and is split into two subsamples in 2008Q3. The sample is split because the global financial crisis is a significant regime change, and it is interesting to analyze whether the behaviour of central banks changed due to it.

We find no significant monetary policy reaction to financial stability measures using our approach. The result is robust across countries, samples and models with different variables. Additionally, reactions to inflation and the output gap vary between countries and models, indicating that the model could be improved in future research.

2 FINANCIAL STABILITY AND MONETARY POLICY

Both financial stability and monetary policy are very current issues. For example, the Bank of England has increased its key interest rate, the bank rate, by 3.25 percentage points to 3.5 per cent in 2022. Before the increase, the bank rate had stayed below 1 per cent for 13 years. (Bank of England, 2022a.) Also, financial stability issues have gained traction after the global financial crisis. However, there is no clear consensus on the definition of financial stability.

This chapter aims to provide foundations for the Taylor rule estimation performed in the later parts of this thesis. First, a brief history of financial stability issues is discussed. Second, definitions for financial stability are presented both from academia and central banks. Third, the objectives and tools of monetary policy are discussed. Finally, the relationship between monetary policy and financial stability is studied. Both theoretical concepts and empirical findings are presented, and the last section focuses on policy considerations.

2.1 Financial stability

Up until the global financial crisis, financial stability was seen by central banks as a secondary objective alongside price stability. The crisis showed that issues stemming from the financial system could cause significant economic disturbances, and thus, the objective of financial stability became more prominent. Before the crisis, the prevalent view was that price stability ensures financial stability in regular times. In crises, the central bank's role was to provide liquidity to the distressed financial system. (Toniolo & White, 2015.)

Financial stability, however, is not a new phenomenon. In the 1800s, financial stability was related to the issue of currency and its regulation. The prevalent view was that protecting currency also protected financial stability. Also, the formation of the Federal reserve system in 1913 was a reaction to the financial instability of the turbulent free banking era in the United States. From the Great Depression until the beginning of the 1970s, financial systems worldwide were under heavy government control and enjoyed financial stability at the cost of inefficiency. The ending of capital controls and deregulation of financial systems in the 1970s led to financial instability and bank failures. (Toniolo & White, 2015.) In response to the turbulent times, central banks published financial stability reports. Following the banking crisis in the early 1990s, the Bank of England published the first financial stability report in 1996. Nordic countries quickly followed suit, and the number of central banks publishing financial stability reports rose from one in 1996 to 40 in 2005. (Oosterloo et al., 2007.) In addition to financial stability reports, regulation was revisited, and the Basel Accords were developed to provide an international framework for regulating the financial system and promoting financial stability. (Toniolo & White, 2015.)

Even though financial stability has become a more prominent issue, there is no consensus on the definition. The following section presents different definitions for financial stability from both academia and central banks.

Crockett (1996) defines financial stability through its counterpart, financial instability. Financial instability is a state of the financial system where asset price fluctuations or disruptions in financial intermediation may cause a decline in economic performance. Financial stability thus means that the financial system functions smoothly, and the volatility of asset prices is not beyond the normal of a competitive market. However, financial instability does not necessarily mean a financial crisis is underway, but the probability of a crisis is heightened. (Crockett, 1996.)

Another pre-crisis definition is provided by Schinasi (2004). According to Schinasi, financial stability is a state of the financial system where the system promotes economic performance and is resilient against the build-up of both endogenous financial imbalances and those triggered by an exogenous shock. When the system is stable, both pricing and resource allocation promote the economy's smooth functioning. Thus, when the financial system is stable, it can efficiently allocate funds and resources to the economy. To be able to perform this task, the system must be able to dissipate financial imbalances, such as excessive increases in asset prices over their fundamentals or unsustainable build-up of credit. (Schinasi, 2004.)

Consequently, financial stability cannot easily be measured as a single numerical value but as a range of values in different indicators of the performance of the financial system, such as interest rate spread volatility and banking system capital. This contrasts with, for example, price stability, for which the inflation rate is accepted as a single numerical indicator. (Schinasi, 2004.)

Allen and Wood (2006) follow Crockett (1996) and define financial stability through financial instability. First, financial stability is the state of the system where the probability of financial instability is low. Financial instability is an episode where in the economy, multiple agents are experiencing simultaneous financial crises that are not caused by their previous actions. These agents include firms, governments, banks, households, and market participants. A single financial crisis might have a minor effect on the functioning of the financial system, but a core feature of financial instability is that collectively these crises cause significant effects on the financial system and the real economy. Also, in a stable financial system, the effect of financial instability on the economic decisions of agents is only marginal. (Allen & Wood, 2006.)

In addition to academia, central banks have also provided definitions for financial stability. ECB defines financial stability as a state of the financial system where the system can perform financial intermediation without disruptions caused by shocks or financial imbalances (European Central Bank, 2023). The Federal Reserve defines financial stability similarly, as a state of the system. A financial system is stable when it efficiently allocates funds from lenders to borrowers (Federal Reserve, 2021b).

The central banks studied in this thesis also provide definitions for financial stability. Bank of England defines financial stability as the consistent supply of services from the financial system to the real economy. These services include means of payment, payment systems, intermediation, insurance, and dispersing risk. (Bank of England, 2017.) For Norges Bank, financial stability is one of its primary objectives. They define a stable financial system where intermediation, payment systems, and distribution of risk work efficiently. (Norges Bank, 2022a.) Sveriges Riksbank has a similar definition as they define financial stability as the efficient functioning of the financial system, in which payment systems, intermediation, and risk management are efficient. (Sveriges Riksbank, 2022a.)

From these definitions, one can conclude that financial stability is considered a state of the system. When the system is stable, financial intermediation is efficient, and the probability of disruptions, and financial instability, is low. For this thesis, we follow Crockett (1996) and define financial stability as the absence of financial instability that can cause adverse effects on the smooth functioning of the financial system and the real economy.

2.2 Monetary policy

Central banks utilize monetary policy and prudential tools to achieve price and financial stability objectives. This thesis focuses on monetary policy and concerns itself less with prudential policies. The main objective for monetary policy is price stability, but after the global financial crisis, including a financial stability objective for monetary policy has gained ground. There are multiple monetary policy tools, which can be split into two categories, conventional monetary policy tools and unconventional monetary policy tools.

2.2.1 Monetary policy objectives

Central banks conduct monetary policy by adjusting key interest rates and liquidity conditions. For the Federal Reserve, the key interest rate is the federal funds rate, which is the interest rate for overnight loans of reserves between banks. Depending on the central bank's objective, a target is set for the key interest rate, and monetary policy tools are used to keep the rate close to the target. Alternatively, in a financial system where banks have reserves with the central bank, the central bank directly sets the key interest rate, usually called the policy rate. (Mishkin, 2016, p. 411.)

The main objective of modern central banks is price stability. The Bank of Finland (BOF) defines price stability as a situation where inflation is predictable and reasonable. Furthermore, when prices are stable, the changes in the price level are no longer necessary factors in agents' decision-making. Price stability is the main objective of the ECB, and it is maintained by setting an inflation target. ECB targets two per cent inflation over the medium term. (Bank of Finland, n.d.)

However, there has been discussion in the literature on whether price stability is enough or if financial stability considerations should be included in monetary policy. Before the global financial crisis, Borio and White (2004) called for monetary policy to consider financial stability by leaning against the build-up of financial imbalances. After the global financial crisis, the discussion has intensified, and three differing views have formed (Smets, 2014). These views are discussed in chapter 2.3.3.

Of the central banks studied in this thesis, all three mention price stability as one of their primary objectives. Bank of England targets two per cent inflation measured by a 12-month increase in the consumer price index (CPI) (Bank of England, 2022c). Norges Bank and Sveriges Riksbank also target a two per cent increase in CPI over one year (Norges Bank, 2022b; Sveriges Riksbank, 2022c). All three central banks mention financial stability in their monetary policy reports, but only Norges Bank explicitly states that it is one of the monetary policy's objectives.

Norges Bank has three objectives for monetary policy. First, Norges Bank pursues two per cent inflation over time in consumer prices. The second objective is maintaining both high and stable output and employment. Finally, the central bank aims to counter the build-up of financial imbalances. The weight of each objective in the Norges Bank's monetary policy model, NEMO, is based on judgment. (Norges Bank, 2022b.)

For Sveriges Riksbank, financial stability is not explicitly a goal of monetary policy, but monetary policy acts to complement prudential policies and supervision in safeguarding financial stability. The Sveriges Riksbank Act states that price stability is the primary objective of monetary policy, and maintaining low unemployment and high economic growth are additional goals. (Sveriges Riksbank, 2022b.)

The monetary policy of the Bank of England has two objectives set in the Bank of England Act 1998. First, the Bank of England maintains price stability, and the operational target is two per cent inflation over one year. Second, the Bank of England supports the economic policy of the British Government. It is acknowledged that in extreme situations, monetary policy could temporarily support macroprudential policies in containing financial imbalances. (HM Treasury, 2021.)

2.2.2 Conventional monetary policy

The three major categories of conventional monetary policy tools are open market operations, reserve requirements, and lending to banks. The actual conduct of each instrument varies across different central banks, but the basic working principles remain the same.

Open market operations are the most important monetary policy tool, as they effectively alter short-term interest rates. Open market operations influence the interest rate through banks' reserves and the monetary base. When a central bank sells assets or performs an open market sale, it decreases the number of reserves and the size of the monetary base. Open market purchase is the converse operation, as a central bank buys assets, consequently increasing both reserves and the monetary base. Open market operations are primarily performed in the treasury market because the market can absorb the size of operations without a significant price change. (Mishkin, 2016, pp. 418–419.) Compared to other conventional monetary policy tools, there are advantages to using open market operations. Open market operations are precise, as their size can vary according to the needed change in reserves or the monetary base (F. S. Mishkin, 2016, pp. 424–425).

The second monetary policy tool used is reserve requirements. Changing reserve requirements affect the money supply through the money multiplier. When reserve requirements are increased, and the monetary base is assumed to stay the same, banks can take in fewer deposits, and consequently, the money supply decreases. Interest rates are also affected as increases in reserve requirements increase the demand for reserves. (Mishkin, 2016, p. 422.)

Lending to banks, or discount policy as called by the Federal Reserve, is the third monetary policy tool central banks use. A central bank has a facility through which it issues loans to banks. For the Federal Reserve, this facility is called the standing lending facility and the marginal lending facility for the European Central Bank. These loans are usually overnight loans that banks can borrow to boost liquidity when needed. The interest rate for short-term loans is set above the policy rate and acts as a ceiling for the policy rate. As banks always have a source of liquidity, even a sudden increase in reserve demand will not drive the policy rate above the lending rate. (Mishkin, 2016, pp. 419–421.)

Bank of England achieves the inflation target set by the Government mainly by adjusting the Bank Rate. Monetary Policy Committee sets the Bank Rate eight times a year, and it is the interest paid on reserves banks deposit in the central bank. The Bank Rate and expectations about it influence market interest rates, which influence economic conditions. (Bank of England, 2022.)

Norges Bank keeps short-term interest rates close to the set policy rate through liquidity management. Liquidity management includes the management of banks' loans and deposits in the central bank and influencing reserves. Liquidity is managed through a quota system, in which the policy rate is paid for a predefined quantity of the bank's reserves, and a lower rate is paid for deposits in excess. The quota system ensures that banks' reserves are kept at an efficient level and that the risks are borne by private agents, not the central bank. (Norges Bank, 2022b.)

Sveriges Riksbank controls market interest rates mainly by influencing the overnight rate through standing facilities and open market operations. Standing facilities create a corridor for the interest rate, where it fluctuates. The deposit facility sets the corridor floor, and the lending facility sets the ceiling. Because of this, commercial banks can always borrow funds from the central bank at the lending rate and deposit at the deposit rate. Rates are derived from the policy rate; the lending rate is 0.10 percentage points higher, and the deposit rate is 0,10 percentage points lower. Consequently, banks are incentivized to borrow and lend to each other overnight at a rate inside the corridor. (Sveriges Riksbank, 2022b.)

In addition to the overnight rate, Sveriges Riksbank controls liquidity using open market operations. Open market operations are performed mainly with Riksbank Certificates, aiming to manage the liquidity conditions in the Swedish financial system. (Sveriges Riksbank, 2022b.)

2.2.3 Unconventional monetary policy

Two commonly used unconventional monetary policy tools are forward guidance and asset purchase programs. Forward guidance means the management of expectations of the public about monetary policy and the policy rate. Forward guidance is beneficial for managing long-term interest rates through short-term interest rates. As the long-term interest rate equals the average of expectations about the short-term interest rate, a central bank can lower both expectations about the short-term and long-term interest rates by committing to a low interest rate for an extended period. Forward guidance has two forms, conditional and unconditional. Conditional forward guidance communicates the monetary policy stance conditional on some other variable, and if the condition is met, monetary policy is expected to be adjusted accordingly. A stricter alternative is unconditional forward guidance, in which monetary policy stance is communicated in a way that indicates that it will not be changed in the near future. (Mishkin, 2016, pp. 430-431.)

Asset purchase programs, called quantitative easing, are large-scale targeted open market operations. They are aimed at a specific sector of the financial system to lower specific interest rates, such as the interest rate on residential mortgages. For example, the Federal Reserve bought mortgage-backed securities in the aftermath of the Lehman Brothers' collapse in 2008 to lower interest rates on mortgages and support the housing market. Another example of an asset purchase program is the QE2 program started in 2010. As the short-term interest rate was already at the zero-lower-bound, the Federal Reserve had to employ unconventional monetary policy to drive the long-term interest rate down and support investment. (Mishkin, 2016, pp. 426.)

In addition to the Bank Rate, the Bank of England utilizes quantitative easing to adjust monetary conditions. Quantitative easing was used between 2009 and 2021 to reach the two per cent inflation target alongside the Bank Rate. In August 2022, the Bank of England started reducing its asset holdings by selling corporate bonds and not reinvesting maturing bonds. (Bank of England, 2022.) In addition to quantitative easing, the Bank of England also uses forward guidance. Monetary Policy Committee announces its policy stance eight times a year, and the announcement includes forward guidance on the future monetary policy stance. For example, December 2022 policy announcement includes conditional forward guidance, “Should the economy evolve broadly in line with the November Monetary Policy Report projections, further increases in the Bank Rate may be required” (Bank of England, 2022e).

For Norges Bank, forward guidance is the second instrument used alongside the policy rate. Asset purchases are not part of the monetary policy toolkit. Norges Bank publishes policy rate forecasts that reflect the best possible policy rate with the central bank’s objectives considered. Monetary policy reports provide further information on the trade-offs and assessments behind policy rate decisions. (Norges Bank, 2022b.)

When deemed necessary, Sveriges Riksbank engages in asset purchases to control interest rates in the economy. For example, Riksbank engaged in asset purchases to mitigate the effects of the Covid-19 pandemic in the spring of 2020. (Sveriges Riksbank, 2022b.) In addition to asset purchases, Sveriges Riksbank engages in forward guidance by regularly publishing forecasts on the policy rate and inflation in the monetary policy report (Ingves, 2020).

2.3 The relationship between financial stability and monetary policy

The relationship between monetary policy and financial stability is multi-dimensional. As the financial system is very complex, there are multiple ways for different monetary policy measures to affect financial stability. Also, the way monetary policy is conducted has its effects.

2.3.1 Theoretical mechanisms

There are multiple ways monetary policy may affect the build-up of financial imbalances and financial stability. This section strongly leans on the literature review by Ajello et al. (2022). They present how monetary policy affects financial stability through different transmission channels.

The interest rate channel is the key transmission mechanism in basic economic models. The transmission mechanism is as follows. As expansive monetary policy decreases real interest rates, capital costs fall, and investment increases. Both output and aggregate demand increase due to this effect. The interest rate channel can be generalized to other asset prices as well. There is, for example, the exchange rate channel that affects net exports. From a financial stability point of view, the housing price channel is of great interest as expansionary monetary policy increases the demand for housing by increasing housing prices. According to Keynesians, expansionary monetary policy decreases interest rates, making bonds less attractive. Demand for other assets, such as housing, increases and causes the prices to climb. (Mishkin, 1996.)

Monetary policy can affect financial stability through asset prices. In models based on the financial accelerator presented by Bernanke et al. (1999), the expansionary monetary policy increases borrowing, increasing the demand for collateral assets. Demand increases the prices of collateral, which enables further borrowing. The build-up of financial imbalances increases due to this feedback loop. (Ajello et al., 2022.) In addition to financial accelerator models, the effect has been studied with models of asset price bubbles.

Allen and Gale (2000) find that in a market with information asymmetries, expansionary monetary policy and low-interest rates shift investors toward riskier assets and cause the prices of risky assets to increase above fundamentals. This risk is shifted to lenders as they have no control over how the investor uses the borrowed funds (Allen & Gale, 2000, as cited in Ajello et al., 2022).

Contrary to the findings supporting the view that relaxed monetary policy fuels asset prices, Galí (2014) uses an overlapping generations model and finds that expansionary monetary policy can contain asset price bubbles in certain situations. The main two findings can be summarized as follows. First, monetary policy can not create bubbles, but it can affect the volatility of the bubble. Second, if the bubble is large, it is optimal for the central bank to relax monetary policy to slow the growth of the bubble. (Galí, 2014.)

Another transmission channel is the credit channel. The credit channel consists of the balance sheet and bank lending channels. The balance sheet channel builds on asymmetric information. Adverse selection and moral hazard problems increase when firms' net economic worth is low. Low net worth firms can provide less collateral, increasing banks' credit losses and decreasing lending and investment in the economy. Also, the owners of low net worth companies are more prone to engage in riskier investments, thus creating a moral hazard problem. (Mishkin, 1996.) In the credit channel, adverse selection can become a problem when the lender cannot identify the characteristics of different borrowers. Because of this, borrowers planning to miss repayments or default can get loans and ultimately cause losses for the lender. (Walsh, 2003, p. 327). Also, moral hazard becomes problematic when borrowers change their behaviour based on the loan contract. The higher the loan costs, the riskier projects become more attractive. (Walsh, 2003, p. 331.)

The way monetary policy works through the balance-sheet channel is as follows. First, the expansionary monetary policy increases asset prices. Second, increases in asset prices increase investment spending as companies' net worth rises. Finally, increases in investment spending cause aggregate demand to increase. Expansionary monetary policy can also affect balance sheets by increasing cash flows by lowering nominal interest rates. (Mishkin, 1996.)

As discussed in the previous section, expansionary monetary policy mitigates issues caused by asymmetric information and consequently increases lending (F. S. Mishkin, 1996). This increase in lending can lead to a build-up of financial imbalances because high net worth households and companies borrow more to finance risky investments or illiquid projects, such as housing and factories. However, the balance sheet channel can also decrease financial imbalances through effects on aggregate output. Expansionary monetary policy and low interest rates cause increases in aggregate output, allowing companies and banks to refinance their existing loans cheaply or deleverage completely, thus decreasing financial imbalances from excess credit. (Ajello et al., 2022.)

The other credit channel is the bank lending channel. Expansionary monetary policy increases reserves and deposits, increasing the number of loans available to the public. As banks lend their increased funds to the public, investment spending and consumption increase. (Mishkin, 1996.) Stein (2012) develops a model to study the relationship between bank lending channels and financial stability. The expansionary monetary policy makes debt cheap and thus an attractive funding source for financial intermediaries. Even though increased lending benefits the economy by increasing consumption and investment, banks are incentivized to excessively use short-term debt to fund lending as they seek profits. This behaviour can facilitate the build-up of financial imbalances in the financial system through excessive leverage. (Stein, 2012.)

In addition to the traditional transmission channels discussed by Mishkin (1996), Borio and Zhu (2008) identify an additional transmission channel called the risk-taking channel of monetary policy. They argue that the changes in interest rates influence risk-taking by shifting perceptions of risk or risk tolerance. This can happen when monetary policy influences risk-taking through asset valuations and income. When a decrease in interest rates causes asset valuations to increase, risk perceptions decrease, and risk tolerance increases (Borio & Zhu, 2008).

Reach-for-yield behaviour is another mechanism of the risk-taking-channel. Dell'ariccia et al. (2010) study bank risk-taking with a model where banks monitor their portfolios' riskiness, and the depth of monitoring and its price are determined inside the system. They find that expansionary monetary policy causes banks to decrease monitoring and take more risks (Dell'ariccia et al., 2010).

Another influential paper on risk-taking and reach-for-yield is by Rajan (2005). Rajan argues that reward schemes cause financial managers to take more tail risk, which means the risk of low-probability events. Additionally, herding behaviour increases risk-taking. As managers are evaluated against a benchmark, they are incentivized to buy the same stocks in the benchmark to ensure their employment. When done by multiple managers, this behaviour may lead to an increase in prices over their fundamentals. As herding behaviour moves prices upwards, the probability of tail losses increases due to the possibility of a significant correction. Expansionary monetary policy can facilitate further risk-taking through two mechanisms. First, as interest rates are low, safer assets become unattractive compared to risky assets. Second, managers get rewards even with low risk-taking when safe returns are high due to higher rates. On the other hand, expansionary monetary policy lowers rates, and managers are forced to turn to riskier assets. (Rajan, 2005.) Lian et al. (2019) also study reach-for-yield behaviour using randomized investment experiments. A relaxed monetary policy leads to a significantly riskier portfolio than a tight monetary policy.

Finally, central bank communication can also influence risk-taking. The current monetary policy, especially forward guidance, signals future monetary policy and changes economic agents' expectations about the future (Ajello et al., 2022.). The more transparent central bank communication is, the more it removes uncertainty about the future and increases risk-taking (Borio & Zhu, 2008).

2.3.2 Empirical findings

The previous section focused on the theoretical mechanisms through which monetary policy influences financial stability. In theory, expansionary monetary policy is seen as a possible facilitator for the build-up of financial imbalances. However, the evidence from empirical literature is limited. This is due to multiple reasons. First, financial cycles are longer than business cycles. This makes it hard to identify the effects of monetary policy from other effects coming from the business cycle. Second, the relationship between monetary policy and financial stability might include nonlinear dimensions, which are hard to estimate with present empirical frameworks. Third, it is hard to separate the effect of expansionary monetary policy from declines in the natural rate of interest coming from other sources. Finally, identifying the effects of systematic monetary policy and monetary policy surprises on financial stability is complicated. (Boyarchenko et al., 2022.)

Boyarchenko et al. (2022) go through multiple empirical studies that study the relationship between monetary policy and financial stability from different perspectives. Studies focus on the period starting in the late 1980s and include conventional and unconventional monetary policy regimes. Study methods include event studies, vector autoregressions, and panel regressions. (Boyarchenko et al., 2022.) Selected studies are discussed below. However, it is good to notice that these studies focus on the United States and the Federal Reserve's monetary policy.

There is an agreement that surprises in monetary policy cause asset prices to adjust (Boyarchenko et al., 2022). Bernanke and Kuttner (2005) study the effect of surprise changes in conventional monetary policy in the short term on stock prices using the event study methodology. They find that a 25 basis point decline in federal funds futures, used as a proxy for surprise monetary policy, leads to a one per cent increase in stock prices. However, this effect explains only a small part of the overall volatility of stock prices. (Bernanke & Kuttner, 2005.)

Lunsford (2020) also uses event study to examine the effect of monetary policy on stock prices with a focus on unconventional policies, especially the communication about the future path of monetary policy, called forward guidance. When forward guidance decreases, the expected path for interest rates, stock prices, and expected GDP growth are both found to decrease. This was found to be the case from 2000 to 2003, but the effect was reversed from 2003 to 2006. The contents of forward guidance are argued to explain the effect. Forward guidance from 2000 to 2003 only consisted of communication about economic conditions. From 2003 to 2006, on the other hand, forward guidance also included communication about the future monetary policy stance. (Lunsford, 2020.) A forward guidance surprise of a one percentage point cut in interest rates is followed by a 23 per cent increase in stock prices. On the other hand, if forward guidance includes only communication about economic conditions and the surprise is equivalent to the previous interest rate cut, stock prices fall by nine per cent. (Boyarchenko et al., 2022.)

Another class of equity that is affected by monetary policy is housing. Kuttner (2014) studies the relationship with a vector autoregression model and finds that 25 basis points decrease in interest rates leads to a 0.3 to 0.9 per cent increase in housing prices. The study indicates that the effect of monetary policy on housing prices is only marginal and is not enough to explain the housing price bubble preceding the global financial crisis. (Kuttner, 2014.) This contradicts Taylor's (2009) argument that the housing bubble and the global financial crisis were caused by relaxed central bank monetary policy. Along the same lines as Kuttner (2014) is Paul (2020), who studies the effect of monetary policy on asset prices in the United States. It is found that monetary policy affects housing prices, but the effect depends on the initial level of housing prices. When initial housing prices are low, the responsiveness of prices to monetary policy is higher than when initial housing prices are high. (Paul, 2020.)

In addition to asset prices, monetary policy influences the amount of leverage for financial intermediaries and the private sector, and the increases in financial leverage cause build-ups in financial imbalances due to making interbank borrowing cheaper. (Boyarchenko et al., 2022). Using panel regression to study monetary policy effects on the leverage of financial intermediaries, Cecchetti et al. (2020) find that prolonged expansionary monetary policy causes banks' leverage ratios to increase from 10.5 to 12.5 after two years. The effect is even more substantial when only the effect of US policy on other countries is considered. In this case, banks' leverage ratios increase from 16.7 to 24.8 over two years. This indicates that the federal reserve’s monetary policy has not only domestic financial stability considerations but also affects the whole world. (Cecchetti et al., 2020.) Turning to household and business leverage, Crouzet (2021) utilizes a panel regression to study the effect. Expansionary monetary policy equivalent to a one percentage point cut in interest rates increases business borrowing by 4.5 percentage points after one year.

Boyarchenko et al. (2022) also feature reach-for-yield behaviour and the risk-taking channel in their study. The research on the topic is mixed, as the influence of monetary policy depends on the type of financial intermediary. Especially for banks, there are no conclusive results. Dell’Ariccia et al. (2013) study the risk-taking channel of monetary policy using a dataset of corporate loans from the United States. They find that relaxed monetary policy and low short-term interest rates increase bank risk-taking, but the effect depends on the bank's capitalization. The effect is more substantial when bank capitalization is high. This behaviour is also present in other financial institutions than banks. Choi and Kronlund (2018) use a panel regression to study reach-for-yield behaviour in the United States corporate bond mutual funds. They find that funds shift towards riskier investments when interest rates are low. One percentage point decrease in one-year treasury yield leads to a four basis point increase in reach-for-yield, defined as the deviation from the benchmark. (Choi & Kronlund, 2018.)

2.3.3 Policy considerations

The previous sections introduced multiple mechanisms through which monetary policy can affect the build-up of financial imbalances and cause financial instability.

Empirical findings on the effect are mixed, yet there has been a lively discussion in the literature on whether central banks should include financial stability considerations in monetary policy. The literature has three differing views on how financial stability should be managed. Smets (2014) identifies these views as A Modified Jackson Hole Consensus, Leaning against the Wind Vindicated, and Financial Stability is Price Stability.

The first view, A Modified Jackson Hole Consensus, argues that monetary policy should focus on maintaining price stability, and macroprudential policies are responsible for financial stability. Before the global financial crisis, according to the *Jackson Hole consensus*, monetary policy should only consider financial stability if it affects price stability and the overall economy. After the crisis, the role of financial stability in the smooth functioning of the economy was realized, and a macroprudential framework was developed. The main point of this view is that macroprudential policies are effective enough to safeguard against financial stability and that there is no need for monetary policy to intervene. (Smets, 2014.) Collard et al. (2017) develop a model that supports this view. In the model, where there are perfectly competitive banks and constant marginal costs, it is optimal for monetary and macroprudential policies to bear different duties.

On the other hand, the Leaning against the Wind Vindicated view promotes using monetary policy to lean aggressively against the build-up of financial imbalances (Smets, 2014). Claudio Borio and William White are renowned advocates for leaning against the wind policy. Borio and Lowe (2002) identify that fast growth in credit coupled with increased asset prices increases the probability of financial instability, even in a low-inflation environment. It is argued that monetary policy should respond directly to the build-up by including a financial stability measure in the policy rule to counter the build-up of financial imbalances. This means that the traditional policy rule, which in its simplest form includes the inflation gap and output gap as measures, is augmented with financial stability measures, such as an indicator of credit growth. White (2006) also argues for financial stability considerations in monetary policy. Longer time horizons and more flexible monetary policy would safeguard price stability and allow the policy to react to the build-up of financial imbalances, such as asset price bubbles.

Woodford (2012) finds supporting evidence for leaning against the wind monetary policy using a model with endogenous variables influencing the probability of a crisis. The study's main finding is that the traditional policy rule that includes an inflation gap and output gap now includes a financial stability measure that can capture the marginal risk of a crisis. When augmented with financial stability measures, monetary policy responds to financial imbalances but can still fulfil the goal of maintaining price stability. (Smets, 2014.)

Finally, the third view advocates for monetary policy that goes beyond traditional inflation targeting and aims to achieve financial and price stability. It is argued that there is no price stability without financial stability; thus, monetary policy’s primary objective should be stabilising the financial system (Smets, 2014). Brunnermeier and Sannikov (2014) develop a macroeconomic model with the financial sector called the I-theory of money. In the model, financial frictions amplify adverse shocks through banks’ balance sheets. If the negative shock produces losses for the bank on the asset side of the balance sheet, banks will try to sell these assets to minimize their risk exposure. However, the firesale of assets causes banks to take on more losses, and balance sheets deteriorate further. As banks' balance sheets deteriorate, they can lend less and money creation in the financial system freezes. The reduction in money supply causes deflationary pressures and increases the real value of the bank’s liabilities, which worsens the situation faced by the bank. (Brunnermeier & Sannikov, 2013.)

These two effects, a liquidity spiral on the asset side of the balance sheet and a deflationary spiral on the liability side of the balance sheet amplify the original negative shock. To counter this amplification effect, monetary policy could be used. For example, decreasing the short-term interest rate could stabilize banks’ balance sheets by increasing the value of long-term bonds. A central bank could also use asset purchase programs to target specific assets to mitigate the amplification effect. (Brunnermeier & Sannikov, 2013.)

3 MONETARY POLICY WITH FINANCIAL STABILITY MEASURE

This chapter first presents the Taylor rule and graphically analyses its three components, inflation, output, and monetary policy indicator. Second, the concept of augmenting the Taylor rule with additional components is discussed. This study aims to find whether the Bank of England, Norges Bank, and Sveriges Riksbank consider financial stability in their monetary policy. One method to achieve this is estimating an augmented Taylor rule with financial stability measure and studying whether the financial stability measure affects the monetary policy indicator in a statistically significant way and has logical signs.

3.1 The Taylor rule

Central banks currently conduct monetary policy by setting a target for the policy rate (F. S. Mishkin, 2016, p. 460). Taylor (1993) presents a simple rule, later called the Taylor rule, in which the policy rate is set equal to the sum of the inflation rate, the equilibrium real policy rate, and the weighted average of the inflation gap and the output gap. The inflation gap is the difference between the inflation rate and the target for inflation, and the output gap is the percentage deviation of real output from its natural level (F. S. Mishkin, 2016, p. 461). One formulation of the Taylor rule is from Käfer (2014) and is as follows.

$$i_t = \bar{r} + \pi_t + \alpha(\pi_t - \pi^*) + \beta(y_t - y^*) \qquad (1)$$

Or in the real interest rate form

$$r_t = i_t - \pi_t = \bar{r} + \alpha(\pi_t - \pi^*) + \beta(y_t - y^*) \qquad (2)$$

Where r_t is the real interest rate
i_t is the policy rate
$\bar{r}$ is the equilibrium real interest rate
π_t is the rate of inflation
π^* is the inflation target

y_t is the output

y^* is the output target

α and β are weights

The inflation gap is presented by $\pi_t - \pi^*$ and $y_t - y^*$ presents the output gap. In the original presentation of the Taylor rule, the inflation target and the equilibrium real interest rate are assumed to be two, and the weights are 0,5. With these assumptions, Taylor (1993) finds that the behaviour of the Federal Reserve fits the rule well between the period from 1987 to 1992. The intuition is that if either the inflation gap or output gap is positive, the real interest rate is higher than the equilibrium real interest rate. In this situation, a central bank should increase the policy rate. (Käfer, 2014.)

3.1.1 Inflation

The first component of the Taylor rule, the inflation gap, is the difference between the inflation rate and the target set by a central bank. For all the central banks studied in this thesis, the inflation target is set at two per cent, and inflation is measured as the change in the consumer price index (CPI). CPI consists of a basket of goods and services; inflation is the price change of goods and services over time. CPI is constructed from aggregate indices, estimated from a sample of prices of a constant group of goods and services. (OECD, 2022.) Total inflation is calculated from a CPI comprising a wide range of goods. Another measure for inflation is core inflation, calculated from a CPI that excludes food and energy products. This exclusion is done because the prices of food and energy products are volatile, and corrections cause the inflation rate to vary. Thus, core inflation better reflects purchasing power.

The data on inflation and core inflation are from the OECD, but the Federal Reserve Economic Data platform is used for access. Data are monthly, aggregated to quarterly frequency, and the period analyzed is from the first quarter of 2000 to the last quarter of 2021. Changes in a consumer price index consisting of all items are used to measure inflation, and changes in a consumer price index less of food and energy items are used to measure core inflation.

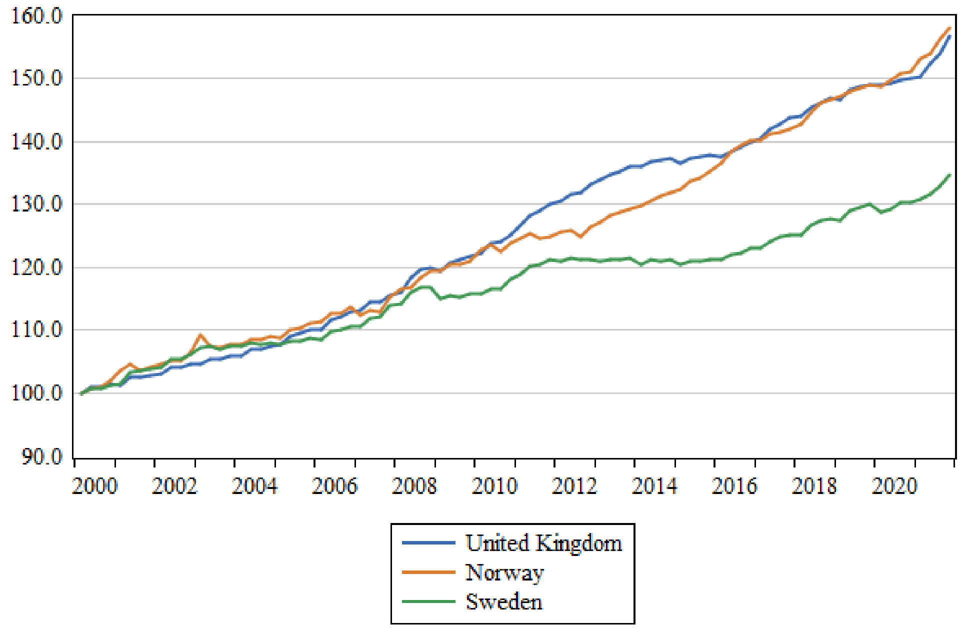

Figure 1. Developments in the Consumer Price Index in the United Kingdom, Norway, and Sweden (2000 = 100), 2000-2021. (Federal Reserve Economic Data, 2023)

Figure 1 presents the quarterly measured consumer price index ranging from 2000 to 2021. Before the global financial crisis, the price development in all three countries was moderate. The differences in price levels between countries were marginal, and volatility was low. During the run-up to the global financial crisis, inflation accelerated in all countries. As we can see from the graph, the price level in Sweden was affected more than in the United Kingdom and Norway, which both continued almost on the same path after the crisis. In Sweden, inflation remained low, around zero per cent, until 2016, when prices increased. In 2021, during the Covid-19 pandemic, inflation started to increase fast, and this trend continued beyond the period presented.

Table 1. Correlation of the Consumer Price Index in the United Kingdom, Norway, and Sweden.

	United Kingdom	Norway	Sweden
United Kingdom	1.0000		
Norway	0.9876	1.0000	
Sweden	0.9865	0.9770	1.0000

Table 1 presents the correlation of the consumer price index between the United Kingdom, Norway, and Sweden from 2000 to 2021. There is a high correlation between countries, at a minimum, 0.977. This indicates that the countries' economies are somewhat similar over time and in structure. Also, as all three countries have a two per cent inflation target, monetary policy's reactions to inflation should have similar characteristics.

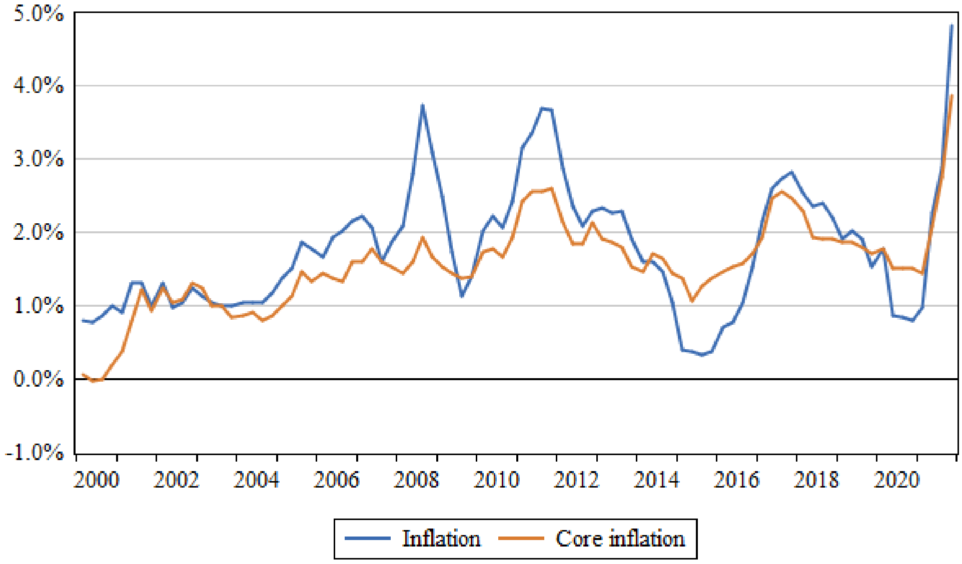

Figure 2. Inflation and core inflation in the United Kingdom, 2000-2021. (Federal Reserve Economic Data, 2023).

Figure 2 presents inflation and core inflation in the United Kingdom between the first quarter of 2000 and the last quarter of 2021. Core inflation has remained stable and close to the two per cent inflation target, excluding 2000, 2001, and 2021. In 2000, core inflation was zero but quickly climbed to close to the target level. In 2021, the gradual ending of the Covid-19 pandemic accelerated inflation and core inflation. In comparison to core inflation, inflation has been more volatile. For example, inflation was 3.7 per cent during the global financial crisis. Also, during the Euro crisis, inflation in the United Kingdom was close to four per cent. During 2015 and 2016, inflation was below core inflation, at 0.5 per cent. In the long term, inflation has stayed around the two per cent inflation target.

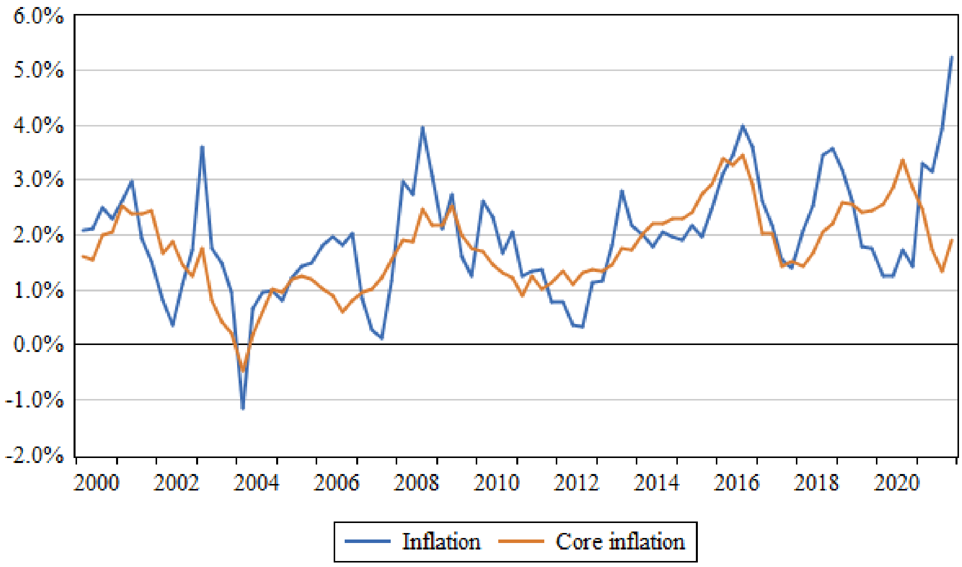

Figure 3. Inflation and core inflation in Norway, 2000-2021. (Federal Reserve Economic Data, 2023).

Compared to the United Kingdom, both inflation and core inflation are more volatile in Norway. Figure 3 presents inflation and core inflation in Norway between 2000 and 2021. Again, core inflation is less volatile than total inflation and is close to the two per cent inflation target over the whole period. In the early 2000s, inflation was very volatile, ranging from 3.5 to -1.2 per cent. In the run-up to the global financial crisis, inflation was initially low, close to zero per cent in 2007, but increased rapidly to four per cent in 2009 before falling to around two per cent in 2010. Inflation fell further to 0.5 per cent, below the core inflation, in 2012. From 2012 onwards, inflation stayed at around two per cent until 2021, when it rapidly increased. In the long term, inflation has varied around the two per cent target.

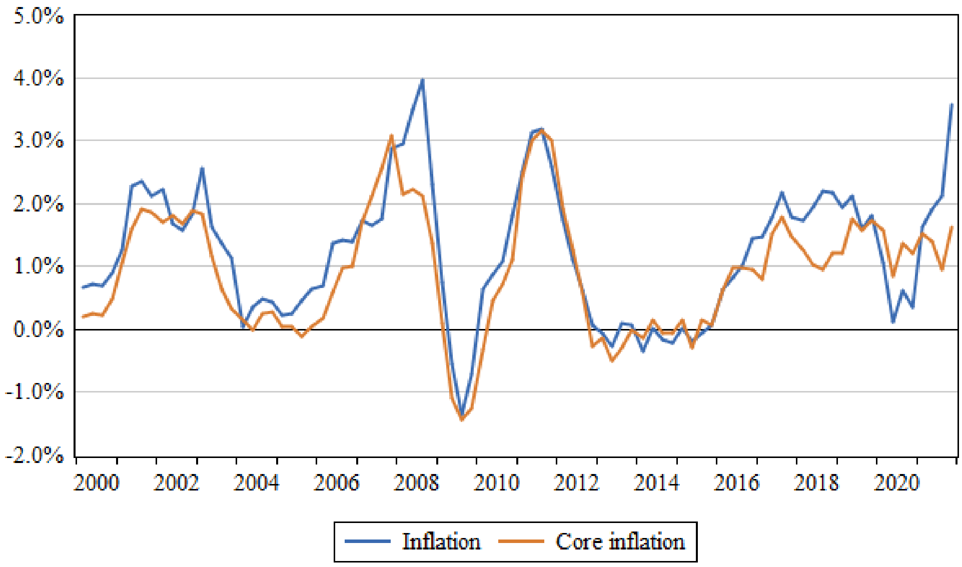

Figure 4. Inflation and core inflation in Sweden, 2000-2021. (Federal Reserve Economic Data, 2023).

Figure 4 presents inflation and core inflation in Sweden from 2000 to 2021. During this period, core inflation has not significantly deviated from inflation, excluding the global financial crisis and the Covid-19 pandemic. Compared to the United Kingdom and Norway, inflation in Sweden has been more volatile, around the two per cent inflation target, being mostly below the target or even negative. After the global financial crisis, inflation was negative before climbing to three per cent. From 2013 to 2016, inflation was around zero and climbed to two per cent afterwards.

3.1.2 Output

The second component, the output gap, is the percentage deviation of real GDP from its natural level. One method to measure natural or potential output is to use the Hodrick-Prescot (HP) filter presented by Hodrick and Prescott (1997). In the analysis below, the smoothing parameter λ is set to 1 600, as suggested by Hodrick and Prescott (1997). [1]

Data on the real GDP is from OECD's main economic indicators but is accessed through the Federal Reserve Economic Data platform. Data is quarterly, and the period analyzed is from 2000 to 2021. The Hodrick-Prescot filter is applied to the natural logarithm of the real GDP, and results are presented in log form, as levels are not of interest in this thesis. The output gap is a percentage difference between the real GDP and the potential.

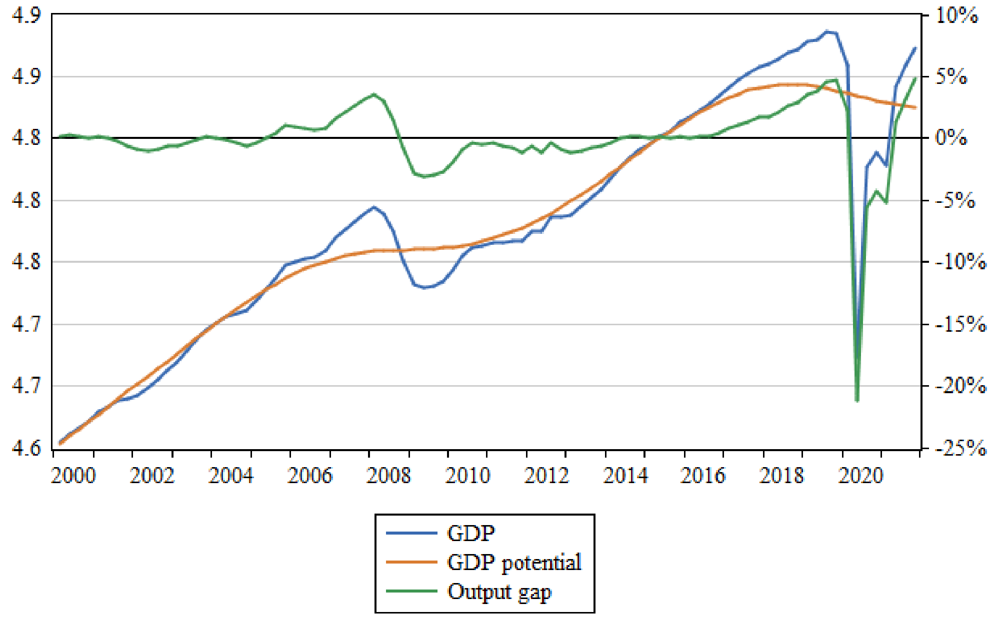

Figure 5. Real GDP and potential real GDP in logs, and the output gap in the United Kingdom, 2000-2021. (Federal Reserve Economic Data, 2023).

Figure five presents the United Kingdom's real GDP and potential real GDP in logs and the output gap as a percentage deviation from 2000 to 2021. Up until 2006, real GDP was at potential, but in the run-up to the global financial crisis, real GDP went above potential, indicating overheating. As the global financial crisis unfolded, GDP

[1] The Hodrick-Prescot filter has been heavily criticized for explaining the data generating process of time series poorly and creating false relationships. See, for example, Hamilton (2018) for further details. However, due to its simplicity, the Hodrick-Prescot filter is used in this thesis.

went below the potential for multiple years, starting from 2009 and ending in 2015. After 2015, real GDP was at potential until the Covid-19 pandemic caused a significant drop in real GDP in 2020. Later in this chapter's estimations, the drop in 2020 is dummied out as an outlier.

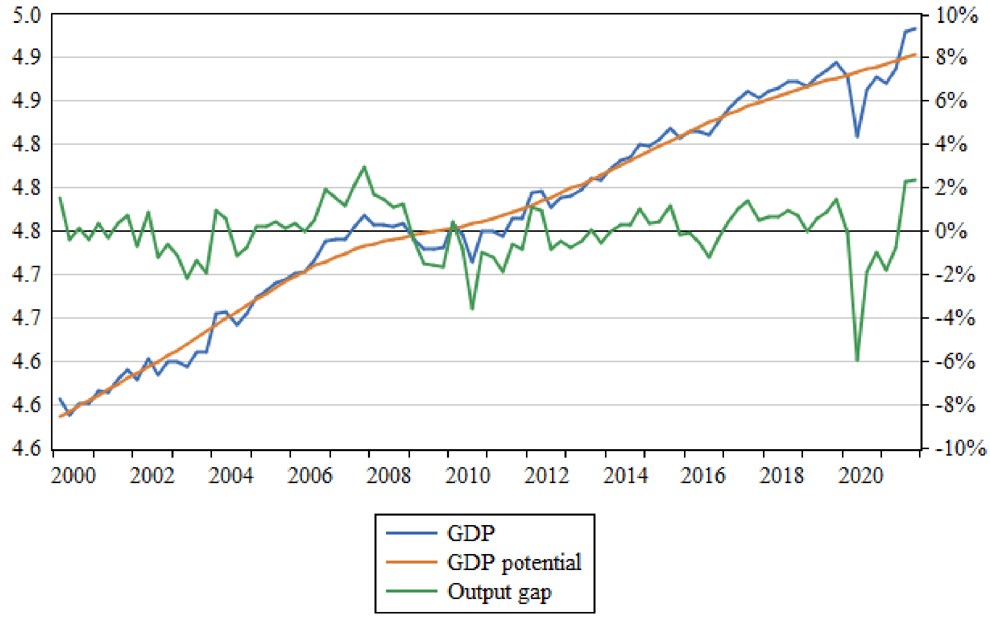

Figure 6. Real GDP and potential real GDP in logs, and the output gap in Norway, 2000-2021. (Federal Reserve Economic Data, 2023).

The real GDP, potential GDP and output gap in Norway from 2000 to 2021 are presented in figure 6. As in the United Kingdom, the real GDP was at or close to potential before the global financial crisis, and the economy overheated in the run-up to the crisis. The global financial crisis unfolding was not as severe in Norway as in the United Kingdom, as real GDP recovered faster and the drop below potential was not as significant. After the crisis, real GDP was around potential until a temporary drop due to the Covid-19 pandemic in 2020. The drop is dummied out in later estimations as with the United Kingdom.

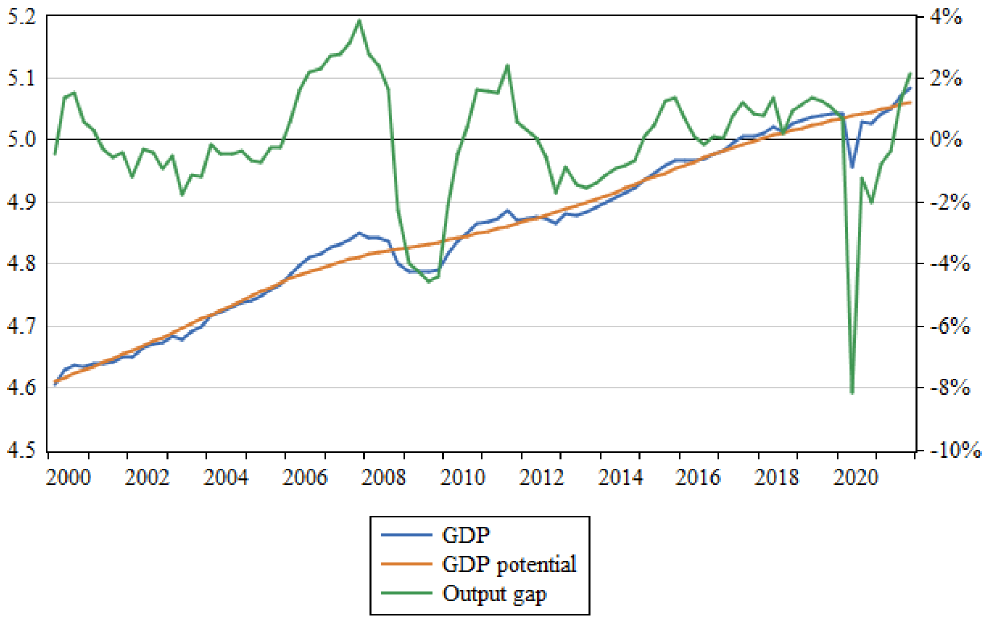

Figure 7. Real GDP and potential real GDP in logs, and the output gap in Sweden, 2000-2021. (Federal Reserve Economic Data, 2023).

Figure 7 presents Sweden's real and potential GDP in logs and the output gap from 2000 to 2021. As in the United Kingdom and Norway, real GDP was at the potential in the early 2000s, but the economy overheated in the years before the global financial crisis. Real GDP fell during and after the crisis, and the output gap widened to -4 per cent. After the crisis, real GDP recovered and stayed around potential until the Covid-19 pandemic, which widened the output gap to -8 per cent. The Covid-19 pandemic will be dummied in the later analysis.

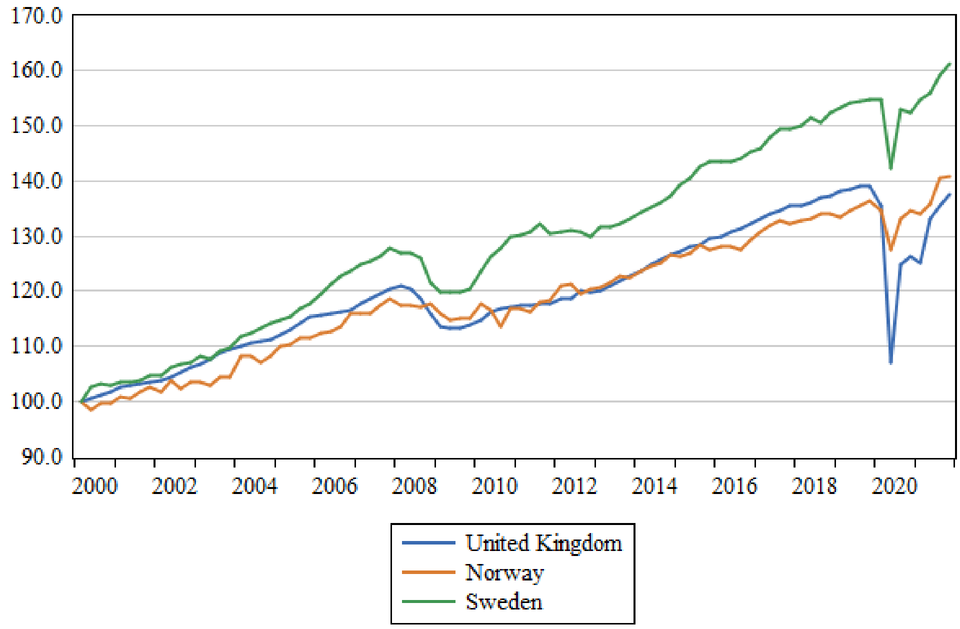

Figure 8. Real GDP in the United Kingdom, Norway, and Sweden (2000=100), 2000-2021. (Federal Reserve Economic Data, 2023).

Figure 8 presents the real GDP for all three countries in indexed form from 2000 to 2021. Countries share similar patterns, with Sweden having the highest growth in real GDP. Growth in Norway and the United Kingdom is similar, but Norway suffered less from the global financial crisis. Also, Norway and Sweden had relatively small drops in real GDP due to the Covid-19 pandemic, but the United Kingdom suffered a significant drop in real GDP.

Table 2. Correlations of real GDP and the output gap in the United Kingdom, Norway, and Sweden.

	United Kingdom		Norway		Sweden	
	RGDP	Output gap	RGDP	Output gap	RGDP	Output gap
United Kingdom	1.0000	1.0000	0.9510	0.7276	0.9494	0.7523
Norway	0.9510	0.7276	1.0000	1.0000	0.9920	0.6356
Sweden	0.9494	0.7523	0.9920	0.6356	1.0000	1.0000

Table 2 presents the correlations of the real GDP and the output gap between the United Kingdom, Norway, and Sweden from 2000 to 2021. Real GDP is highly correlated between the countries, with values above 0.9 for each country and 0.99 between Norway and Sweden. The output gap also correlates between the three countries, but the value is only 0.75 between the United Kingdom and Sweden, 0.73 between the United Kingdom and Norway, and 0.64 between Norway and Sweden. These values indicate that countries' economies have somewhat similar structures and experience similar business cycles. According to this, the monetary policy reaction to the output gap should be similar between countries, but the similarity is less pronounced than with inflation.

3.1.3 Monetary policy indicators

As discussed in the previous chapter, monetary policy can be conducted by conventional and unconventional policies. Setting the policy rate at a desired level has traditionally been the prevalent method, but quantitative easing has been used excessively after the global financial crisis. Of the central banks studied, the Bank of England and Sveriges Riksbank both utilize quantitative easing (Bank of England, 2022c; Sveriges Riksbank, 2022b). Conversely, Norges Bank does not employ quantitative easing but focuses its monetary policy on the policy rate and forward guidance (Norges Bank, 2022b).

For this study, in the case of Norway, it is enough to consider the policy rate when presenting monetary policy. However, the policy rate is insufficient for the Bank of England and Sveriges Riksbank. After the global financial crisis, quantitative easing has been used alongside the policy rate to manage interest rates because the policy rate has been at, or close to the zero-lower-bound. Thus, looking only at the policy rate is insufficient to present monetary policy as a whole accurately. Wu and Xia (2016) have developed a shadow rate that considers the effects of unconventional monetary policy to solve this issue. The shadow rate can be negative, and it thus eliminates the problem posed by the zero-lower-bound. The version of the shadow rate used in this thesis is by De Rezende and Ristiniemi (2023). They use data on daily yield curves to estimate shadow rates for the United States, Sweden, the euro area, and the United Kingdom. Their study is used over Wu and Xia (2016) because it readily includes estimations for Sweden and the United Kingdom.

Data for the shadow rate is readily available for the United Kingdom and Sweden. Original daily data is from De Rezende and Ristiniemi (2023), and in this thesis, the data is transformed into quarterly form by taking averages. For Norway, the data on the policy rate is from the Norges Bank API for open data (Norges Bank, 2023) and is daily data transformed into quarterly form by taking averages. For both datasets, the period studied is from 2000 to 2021.

The shadow rate is presented in two different forms, with a pricing factor of two (p = 2) and a pricing factor of three (p = 3). These factors are parameters of the discrete-time Gaussian Dynamic Affine Term Structure model (DATSM) De Rezende and Ristiniemi (2023) utilize, and they affect the shape of the term structure and, consequently, the shadow rate. However, this topic is beyond this thesis's scope, and the pricing factors will be taken as they are and will not be pursued further. The analysis in part four is done with the pricing factor of three.

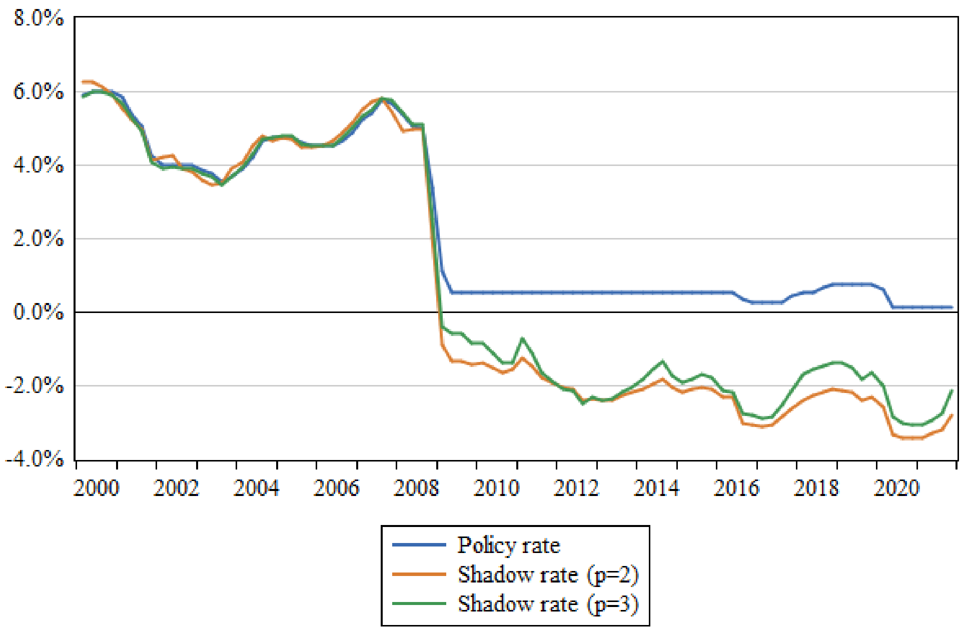

Figure 9. Policy and shadow rates in the United Kingdom, 2000-2021. (De Rezende & Ristiniemi, 2023a).

Figure 9 presents the policy and shadow rates in the United Kingdom from 2000 to 2021. Shadow rates with two and three pricing factors show only a slight variation; using either is appropriate for this thesis. Before the global financial crisis, the policy and shadow rates followed a similar path, between four and six per cent, with only marginal differences. In 2008, monetary policy was quickly relaxed, and the policy rate was lowered from five per cent to 0.5 per cent in the period beginning in October 2008 and ending in March 2009. After the global financial crisis, the policy rate has stayed low, between 0.75 and 0.1 per cent. Of course, outside the period analyzed in this thesis, the policy rate has increased again, ending the decade of low-interest rates.

On average, the shadow rate (p = 2) differed from the policy rate by 0.22 percentage points before the global financial crisis. In the aftermath of the crisis, the shadow rate diverged from the policy rate, and the difference has been, on average, 2.63 percentage points, with the shadow rate being negative and lower than the policy rate. The divergence in 2008 was due to a highly expansionary monetary policy consisting of policy rate cuts and quantitative easing. For example, a significant asset purchase program starting in February 2009 led to shadow rates falling by 0.47 percentage points (De Rezende & Ristiniemi, 2023).

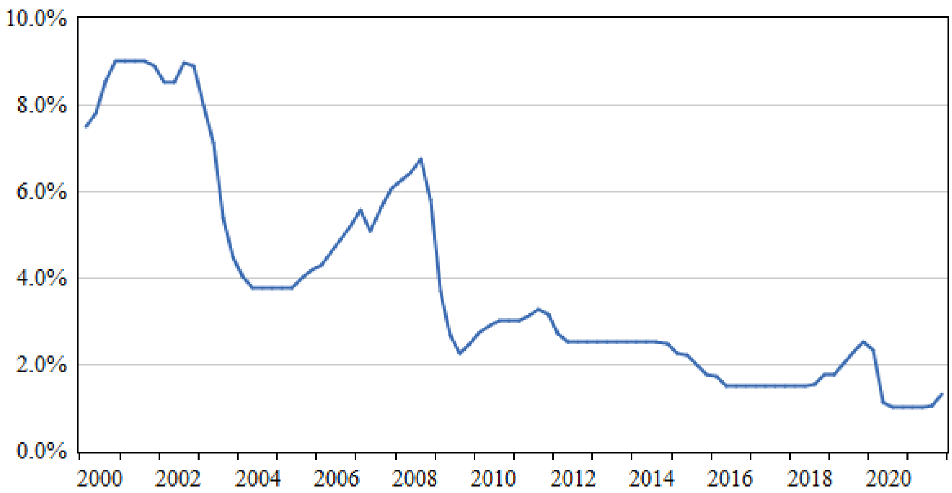

Figure 10. Policy rate in Norway, 2000-2021. (Norges Bank Statistics, 2023).

Figure 10 presents Norges Bank's policy rate developments from 2000 to 2021. Initially, the policy rate was at a high level, around nine per cent, but starting in December 2002, it was gradually lowered to 3.75 per cent. In the run-up to the global financial crisis, the policy rate increased, and it peaked at 6.75 per cent in August 2008. During the crisis, the policy rate was quickly lowered to 2.25 per cent, starting in August 2008 and ending in July 2009. Afterwards, the policy rate fluctuated around two per cent until the end of the analysis period. As with the United Kingdom, the policy rate increased quickly outside the analysis period.

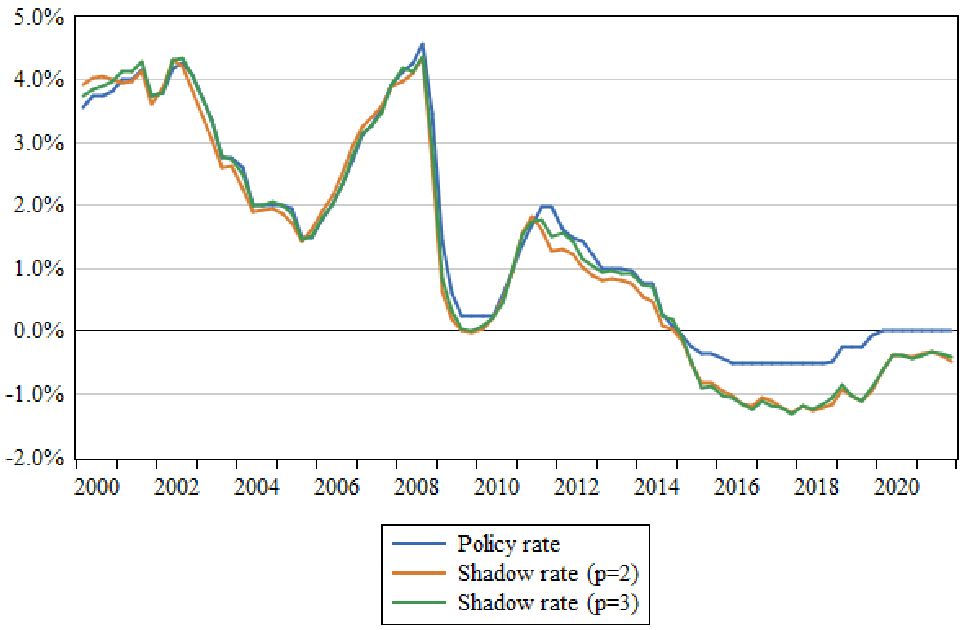

Figure 11. Policy and shadow rates in Sweden, 2000-2021. (De Rezende & Ristiniemi, 2023a).

Figure 11 presents Sweden's policy and shadow rates from 2000 to 2021. As with the United Kingdom, shadow rates with two and three pricing factors are marginally the same, so using either in the analysis is appropriate. Before the global financial crisis, the policy and shadow rates followed the same path. First, the monetary policy was relaxed, and the interest rates dropped from around four per cent in 2002 to 1.5 per cent in 2005. In the run-up to the global financial crisis, monetary policy was tightened, and rates peaked at 4.75 per cent in 2008. As the crisis erupted, the monetary policy was relaxed, and the policy rate was gradually lowered to 0.25 per cent. During the European debt crisis, beginning in 2009, the monetary policy was again tightened, and the policy rate peaked at two per cent. Afterwards, the policy rate was gradually lowered to -0.5 per cent, where it stayed until late 2018, when the policy rate was raised first to -0.25 per cent and finally to zero per cent. As with the United Kingdom, the monetary policy has significantly tightened outside the period analyzed in this thesis.

The shadow rate (p = 2) differed from the policy rate on average by only 0.21 percentage points until diverging in 2015. The divergence was due to the beginning of a bond purchase program on the 12th of February, 2015. Also, Sveriges Riksbank set a negative policy rate for the first time in its history, as it was set to -0.10 (De Rezende & Ristiniemi, 2023). Afterwards, the difference between the policy rate and the shadow rate was, on average, 0.59 percentage points, peaking at 0.97 percentage points in September 2019, with the shadow rate below the policy rate.

3.2 Augmented Taylor rule with financial stability measure

After the first presentation of the Taylor rule by Taylor (1993), the rule was modified and extended to include, for example, the expected inflation gap and output gap (Clarida et al., 1998) or indicators of financial conditions (Bernanke & Gertler, 2000). Extensions aim to explain the behaviour of central banks better by including additional explanatory variables into the equation, an example being a financial stability measure. Also, the augmented Taylor rule can be used to study if a central bank considers certain factors, such as asset prices, in its monetary policy decisions. A simple form of the augmented Taylor rule is from Käfer (2014) and is as follows.

$$i_t = \bar{r} + \pi_\tau + \alpha(\pi_t - \pi^*) + \beta(y_t - y^*) + \gamma(x_t - x^*) \quad (3)$$

Where x_t is the financial stability measure
x^* is the target for financial stability measure
γ is a coefficient

Multiple candidates for the financial stability measure can be found in the previous chapter. For example, stock and housing prices can cause financial instability when imbalances grow excessively (Ajello et al., 2022). Monetary policy can also worsen or unwind these imbalances, depending on the stance (Bernanke & Kuttner, 2005; Kuttner, 2014). Also, monetary policy can influence the leverage of financial intermediaries, businesses, and households (Ajello et al., 2022), and when prolonged, relaxed monetary policy is found to increase banks' leverage ratios substantially (Cecchetti et al., 2020).

Both asset prices and leverage are present in financial stability reports published by central banks. The Federal Reserve, for example, has a standard set of four financial vulnerabilities that it monitors frequently. The findings are published yearly in the financial stability report. Financial vulnerabilities monitored are asset prices, private-sector borrowing, leverage in the financial system, and funding risks. (Federal Reserve, 2022.) The Bank of England publishes financial stability reports semiannually. The report includes an economic outlook and analyses of financial market developments, debt, and banks' resilience (Bank of England, 2022d). Norges bank publishes financial stability reports annually and monetary policy reports with financial stability assessments quarterly. Critical financial vulnerabilities monitored are household debt, asset prices, and banks' risk exposure. (Norges Bank, 2022a.) For Sveriges Riksbank, the principal vulnerabilities monitored are asset prices, debt, and leverage, and developments are published semiannually in the financial stability report (Sveriges Riksbank, 2022a).

Augmenting the Taylor rule with a financial stability measure has been experimented with in academic literature. Käfer (2014) provides an extensive literature review focusing on the Eurozone. Studies discussed fall into four categories. Studies in the first category augment the Taylor rule with the exchange rate and find that interest rates respond to changes in exchange rates, but the response is only marginal. (Käfer, 2014.) Exchange rates are not considered in this master's thesis and thus will not be pursued further.

The second category consists of asset prices, especially stock and housing prices. There is a broad consensus that central banks should not mechanically target asset prices but use discretion in reactions. Empirical findings suggest that central banks have reacted to asset prices, but it is unclear whether the reaction is separate from reactions to inflation and output. (Käfer, 2014.)

In addition to asset prices, the Taylor rule has been augmented with credit and leverage. The motivation behind this is that when asset price bubbles are combined with excessive credit growth, the burst of the bubble can cause a costly financial crisis (Borio & Lowe, 2002, 2004). Empirical studies on the topic find that monetary policy targeting leverage accompanied by capital regulation can stabilize the financial system, and in some cases, the Taylor rule augmented with credit is superior to the standard rule. (Käfer, 2014.)

Finally, different spreads have been used to augment the standard Taylor rule. The policy rate is an anchor on which all the other interest rates used in the financial system are based. Thus, lowering the policy rate lowers the interest burden and the probability of severe economic stress. Empirical studies have found that the outcome is improved when the Taylor rule is augmented with credit spreads. However, as the field of using spreads is new compared to other categories, the results have many uncertainties. (Käfer, 2014.)

From the previous discussion, asset prices and borrowing stand out as potential financial (in)stability measures. Leverage is left out of the analysis because data is difficult to obtain. The following sections discuss the developments in these three measures in the United Kingdom, Norway, and Sweden.

3.2.1 Asset prices

Asset valuation is the price of an asset net of economic fundamentals. When valuations are high compared to historical valuations or economic conditions, they are considered a vulnerability. An unwinding asset price bubble can cause destabilizing effects on the financial system and the real economy. (Federal Reserve, 2021.)

The data on stock and housing prices are from the OECD but are accessed through the Federal Reserve Economic Data platform. Moreover, they are indexed to remove currency-related issues and make comparisons easier. The data is monthly but averaged to a quarterly form, and the period analyzed is from the first quarter of 2000 to the last quarter of 2021. The stock price data consists of the prices of shares traded in national and international stock exchanges (OECD, 2023b). The data on housing prices consist of the real housing prices of new and existing dwellings (OECD, 2023a).

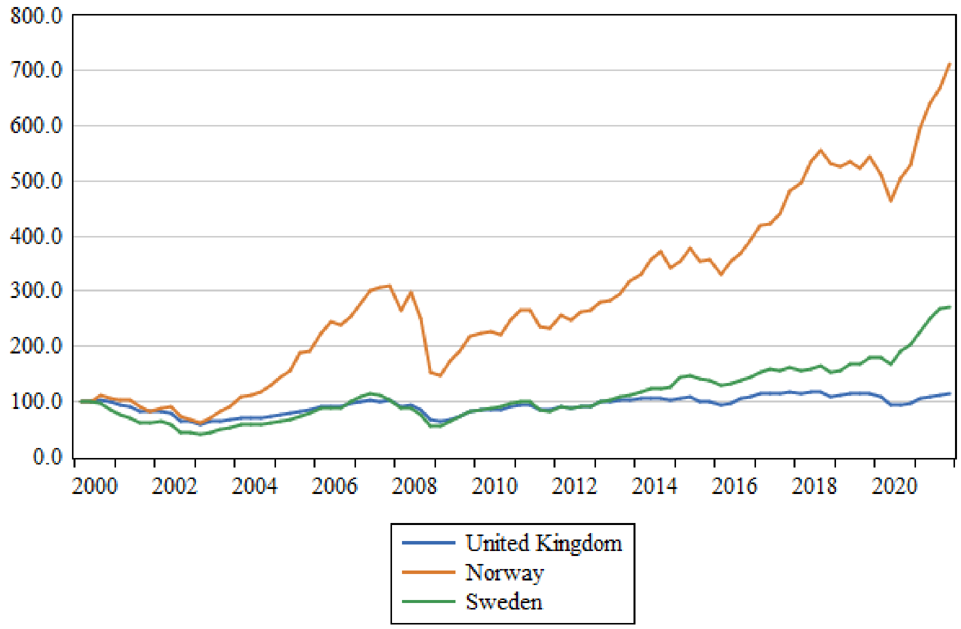

Figure 12. Stock price development in the United Kingdom, Norway, and Sweden (2000 = 100), 2000-2021. (Federal Reserve Economic Data, 2023).

Figure 12 presents the indexed stock prices from 2000 to 2021 in the United Kingdom, Norway, and Sweden. In the early 2000s, the stock prices in all three countries followed a similar path. However, in the run-up to the global financial crisis, growth in Norway diverged from the other countries and over tripled in value before the bubble burst in 2008. Developments in the United Kingdom and Sweden were more modest, with stock prices almost doubling. During the crisis, stock prices fell in all three countries but recovered shortly afterwards.

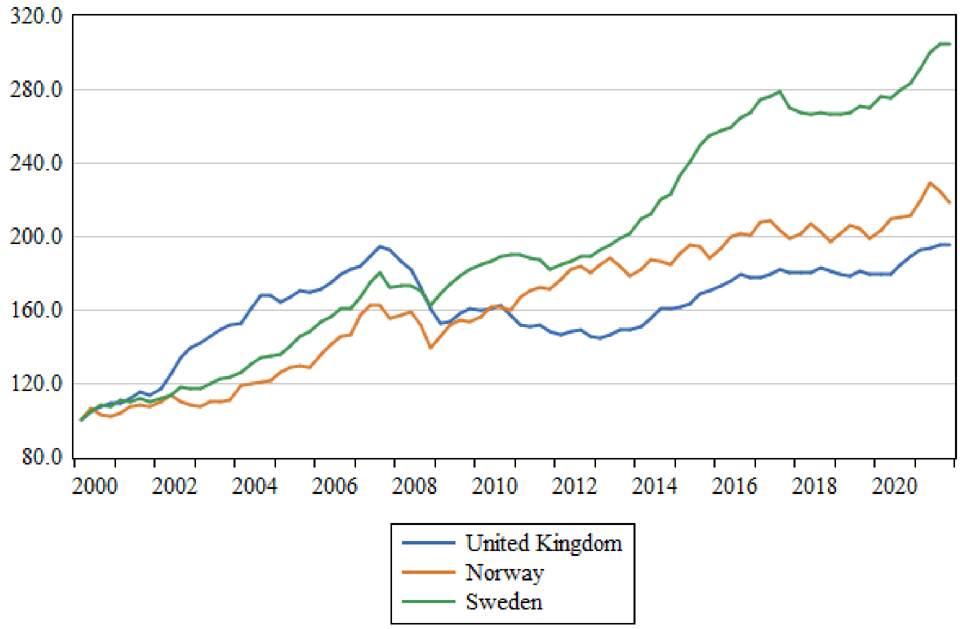

Figure 13. Developments in real housing prices in the United Kingdom, Norway, and Sweden (2000 = 100) 2000-2021. (Federal Reserve Economic Data, 2023).

Figure 13 shows the developments in the indexed housing prices in the United Kingdom, Norway, and Sweden from 2000 to 2021. Housing prices show similar patterns as stock prices, with prices increasing in the early 2000s and accelerating in the run-up to the global financial crisis. Starting in 2000 and ending in 2007, housing prices nearly doubled in the United Kingdom and increased over 50 per cent in Norway and Sweden. During the crisis, housing prices fell sharply in all countries but recovered quickly in Norway and Sweden. In the United Kingdom, growth in housing prices was slow in the years following the global financial crisis, only reaching the pre-crisis level in 2021.

Table 3 Correlations in stock and property prices in the United Kingdom, Norway and Sweden.

	United Kingdom		Norway		Sweden	
	Stock prices	Property prices	Stock prices	Property prices	Stock prices	Property prices
United Kingdom	1.0000	1.0000	0.8037	0.6904	0.7976	0.7165
Norway	0.8037	0.6904	1.0000	1.0000	0.9501	0.9708
Sweden	0.7976	0.7165	0.9501	0.9708	1.0000	1.0000

Correlations in stock and housing prices between the United Kingdom, Norway, and Sweden from 2000 to 2021 are presented in table 3. For Norway and Sweden, stock and housing prices correlate highly, as values are 0.95 and 0.97, respectively. Also, the stock prices in the United Kingdom correlate with Norway and Sweden. On the other hand, housing prices in the United Kingdom are not as correlated with Norway and Sweden, as values are 0.69 and 0.72, respectively. As with the real GDP and the consumer price index, these findings indicate that Norway and Sweden are similar economies. The United Kingdom is also similar, but this is less pronounced.

3.2.2 Borrowing

In addition to asset prices, central banks monitor borrowing by businesses and households. A high level of borrowing leaves borrowers vulnerable to shocks coming from, for example, a fall in income or the value of an investment portfolio. These shocks can cause borrowers to decrease spending dramatically, causing a drop in economic activity. A shock can cause a borrower to have difficulties paying back loans or, in the worst-case scenario, default. This, in turn, stresses the financial system as financial intermediaries incur losses. (Federal Reserve, 2021.)

The data on borrowing is from the Bank of International Settlements, accessed through the Federal Reserve Economic Data platform. The data are quarterly, from 2000 to 2021, and adjusted for breaks. The data consists of borrowing from banks, financial institutions, and non-financial companies. Borrowers are the private non-financial sector, including companies and households. (BIS, 2023.)

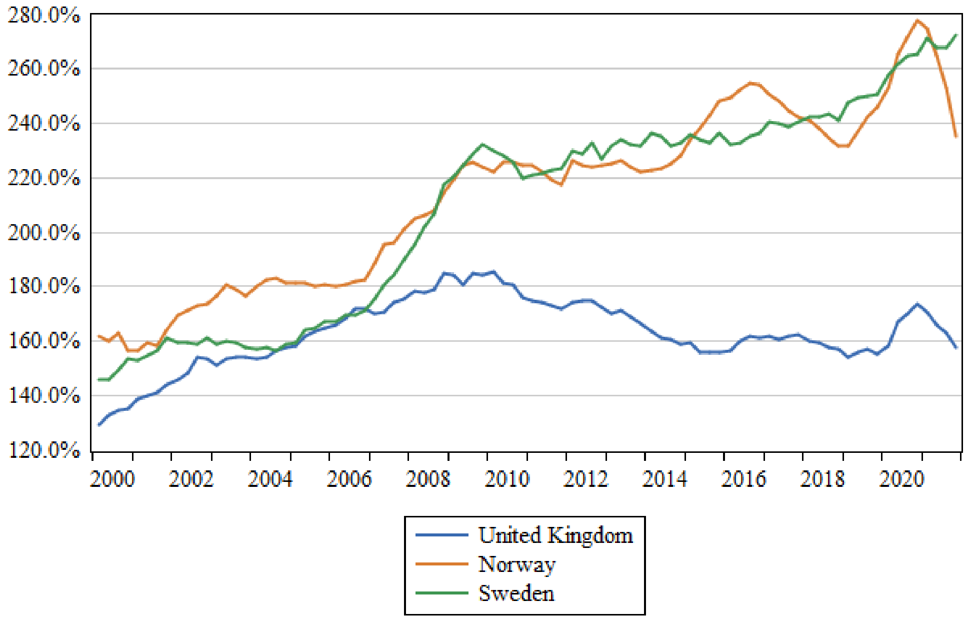

Figure 14. Total credit to the private sector in the United Kingdom, Norway, and Sweden 2000-2021. Percentage of GDP. (Federal Reserve Economic Data, 2023).

Figure 14 presents the total credit to the private sector in the United Kingdom, Norway, and Sweden from 2000 to 2021 as a percentage of GDP. Norway and Sweden exhibited a similar path through the period, but the similarity became more evident after the global financial crisis. In the United Kingdom, the global financial crisis caused a downward trend in the private sector's total credit.

Table 4 Correlation in total credit to the private sector in the United Kingdom, Norway and Sweden.

	United Kingdom	Norway	Sweden
United Kingdom	1.0000	0.4459	0.4494
Norway	0.4459	1.0000	0.9632
Sweden	0.4494	0.9632	1.0000

The correlation of total credit to the private sector between the United Kingdom, Norway, and Sweden is presented in table 4. The total credit in Norway is highly correlated with the total credit in Sweden, but both correlate only weakly with the total credit in the United Kingdom. Again, this indicates that Norway and Sweden have very similar private debt structures, and the structure in the United Kingdom shares some similarities.

4 MODEL AND ESTIMATION

This chapter addresses if central banks consider financial stability when setting monetary policy. The econometric model estimation is done separately for Norway, Sweden, and the United Kingdom. The period analyzed is from 2000 to 2021, and analysis is done with quarterly data. Both the data and variables used are described in detail in chapter three. Abbreviations for variables are defined in appendix 1.

Theory and empirical findings suggest a connection between monetary policy and financial stability, but there is no consensus on the magnitude and whether central banks should react to financial stability. We hypothesise that the Taylor rule works well in the period preceding the global financial crisis and that the inflation and output gap variables have positive and statistically significant coefficients. However, we hypothesise that the Taylor rule works for the period beginning after the global financial crisis, but the relationships are weaker than in the pre-crisis period. For financial stability measures, we expect results to vary between countries, periods, and model specifications. We expect that monetary policy weakly reacts to increases in financial stability measures.

4.1 Model

The model estimated is an Augmented Taylor rule based on the work of Taylor (1993). In the model, the dependent variable is a monetary policy indicator, either the policy rate or the shadow rate. The dependent variable is explained using many explanatory variables, including inflation, core inflation, output gap, stock prices, property prices, and total credit to the private sector. Equation 4 presents the augmented Taylor rule used in estimations.

$$r_t = \alpha_0 + \alpha_1 y_t + \alpha_2 \pi_t + \alpha_3 x_{1t} + \cdots + a_n x_{it} + \varepsilon_t \tag{4}$$

Where r_t is the monetary policy indicator

y_t is the output gap

π_t is inflation

x_{it} is the financial stability measure, i = 1,2, …, i

ε_t is the error term

Model selection begins with unit root testing. Because the data includes a significant regime change, the global financial crisis, the analysis is conducted on two subsamples separately. The sample is split into two at 2008Q3; the first subsample is from 2000Q1 to 2008Q3, and the second subsample is from 2008Q4 to 2021Q4. Subsamples are tested separately, and the Augmented Dickey-Fuller (ADF) unit root test results can be found in appendix 2. The lag length is automatically chosen using the Schwarz information criterion (SIC) with a maximum lag length of 8. If the p-value is under 0,05, the variable is stationary.

All variables are stationary at levels or the first difference in the full sample, either with constant or constant and trend. Only the real residential property prices in the United Kingdom are stationary at the first difference at a 10 per cent level of significance. Other variables are stationary at the 5 per cent level of significance.

In the sample from 2000Q1 to 2008Q3, nonstationarity cannot be rejected for real residential property prices in Norway and the United Kingdom, the policy rate in Norway and the United Kingdom, stock prices in Norway, Sweden and the United Kingdom, total credit to the non-financial private sector in Sweden, and the shadow rate with pricing factor of three in the United Kingdom. Other variables are stationary at a 5 per cent significance level with constant, and constant and trend. Further analysis is required to determine whether nonstationarity can be rejected.

Table 5 DF-GLS unit root tests, 2000Q1 – 2008Q3.

	Level				First Difference			
	Constant		Constant and Trend		Constant		Constant and Trend	
NOR_PROPERTY	-2.4372		-3.3338	**	-2.2370	**	-2.1813	
NOR_RATE	-1.6351	*	-1.7376		-2.4620	**	-2.6242	
NOR_STOCKS	-0.7679		-1.9098		-2.0904	**	-2.2018	
SWE_CREDIT	1.0975		-1.3834		-1.1587		-2.1406	
SWE_STOCKS	-1.5439		-1.9234		-2.9203	***	-2.9421	*
UK_PROPERTY	-1.6260	*	-1.3584		-0.5221		-1.5820	

UK_RATE	-2.0691	**	-2.3365	-2.6977	***	-2.8928	*
UK_SHADOW3	-2.0230	**	-2.3152	-2.7138	***	-2.9127	*
UK_STOCKS	-1.8421	*	-2.1931	-2.0347	**	-2.0680	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Table 5 presents the Dickey-Fuller Generalized Least Squares (DF-GLS) unit root test results for the nonstationary variables in the sample from 2000Q1 to 2008Q3 according to the ADF unit root test. We choose lag length automatically according to SIC with a maximum lag length of 8. With the DF-GLS, all variables are stationary at levels or first difference, except total credit to the non-financial private sector in Sweden. Also, real residential property prices in the United Kingdom are stationary at levels with only a 10 per cent level of significance.

In the sample from 2008Q4 to 2021Q4, all variables are stationary at levels or first difference at a 5 per cent level of significance, except for real residential property prices in the United Kingdom, which are stationary at a 10 per cent level of significance. The significant drop in output gaps in 2020Q2 is dummied from the sample as an outlier.

Because we study time series data with possible long-run relationships, we choose Autoregressive Distributed Lag (ARDL) model for our analysis. ARDL modelling begins with estimating a conditional error correction model. In the model, the differenced regressand, Δr_t, is explained with the lagged value of the regressand, r_{t-1}, lagged values of regressors y_{t-1}, π_{t-1} and x_{t-1}, and the lagged differences Δr_{t-i}, Δy_{t-j} $\Delta \pi_{t-k}$ and Δx_{t-l}. The optimal lag lengths $i,\ j$, k and l can be determined with, for example, the Akaike information criterion (AIC) or Schwarz information criterion (SIC). In this thesis, AIC is used for the selection of lag length. Equation 5 shows the conditional error correction model following Huikari (2023).

$$\Delta r_t = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 y_{t-1} + \alpha_3 \pi_{t-1} + \alpha_4 x_{t-1} + \sum_{1=1}^{p-1} \beta_i \Delta r_{t-i} + \sum_{j=0}^{q=1} \delta_j \Delta y_{t-j} + \sum_{k=0}^{s-1} \mu_k \Delta \pi_{t-k} + \sum_{l=0}^{u-1} \theta_l \Delta x_{t-l} + u_t \quad (5)$$

For the ARDL model to be appropriate, all variables must be stationary at levels or first differences. The bounds test by Pesaran, Shin and Smith (2001) is used to test variables for cointegration and requires that all variables used are I(0) or I(1). The previous unit root testing shows that every variable except total credit to the non-financial private sector in Sweden and real residential property prices in the United Kingdom in the pre-crisis sample is stationary at a 5 per cent significance level or less. In the sample from 2008Q4 to 2021Q4, all variables except the real residential property prices in the United Kingdom and credit in Sweden are stationary at a 5 per cent level of significance. Because of the nonstationarity in either sample, the real residential property prices in the United Kingdom and total credit to the private sector in Sweden are removed to keep models comparable.

The bounds test by Pesaran et al. (2001) is based on F-statistic and t-statistic and tests whether variables r_t, π_t y_t and x_t are cointegrated. The null hypothesis that the long-term parameters are zero is first tested with the F-test.

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$$

The null hypothesis is rejected if the F-statistic exceeds the upper critical value of the bounds test. If the null hypothesis is rejected, the first long-term parameter, α_1, is tested with the t-test.

$$H_0: \alpha_1 = 0$$

If the F-test and the t-test reject their respective null hypotheses, variables are cointegrated, and we can estimate an ARDL model. If, however, the F-statistic or t-statistic is below the lower critical value, there is no cointegration. There is no conclusion if the value is between the lower and upper critical values. For the models that indicate cointegration, an ARDL model can be estimated.

$$r_t = \rho_0 + \sum_{i=1}^{p} \lambda_i r_{t-i} + \sum_{j=0}^{q} \eta_j y_{t-j} + \sum_{k=0}^{s} \omega_k \pi_{t-k} + \sum_{l=0}^{u} \varphi_l x_{t-l} + v_t \qquad (6)$$

The following must be true if the variables have a long-run relationship.

$$r^* = r_t = r_{t-1} = \cdots = r_{t-p}$$

$$y^* = y_t = y_{t-1} = \cdots = y_{t-p}$$

$$\pi^* = \pi_t = \pi_{t-1} = \cdots = \pi_{t-p}$$

$$x^* = x_t = x_{t-1} = \cdots = x_{t-p}$$

The long-run parameters can be derived as follows.

$$r_t = \rho_0 + \sum_{i=1}^{p} \lambda_i r_t + \sum_{j=0}^{q} \eta_j y_t + \sum_{k=0}^{s} \omega_k \pi_t + \sum_{l=0}^{u} \varphi_l x_t$$

$$\Rightarrow r_t - \sum_{i=1}^{p} \lambda_i r_t = \rho_0 + \sum_{j=0}^{q} \eta_j y_t + \sum_{k=0}^{s} \omega_k \pi_t + \sum_{l=0}^{u} \varphi_l x_t$$

$$\Rightarrow \left(1 - \sum_{i=1}^{p} \lambda_i\right) r_t = \rho_0 + \sum_{j=0}^{q} \eta_j y_t + \sum_{k=0}^{s} \omega_k \pi_t + \sum_{l=0}^{u} \varphi_l x_t$$

$$\Rightarrow r_t = \frac{\rho_0}{\left(1 - \sum_{i=1}^{p} \lambda_i\right)} + \frac{\sum_{j=0}^{q} \eta_j}{\left(1 - \sum_{i=1}^{p} \lambda_i\right)} y_t + \frac{\sum_{k=0}^{s} \omega_k}{\left(1 - \sum_{i=1}^{p} \lambda_i\right)} \pi_t + \frac{\sum_{l=0}^{u} \varphi_l}{\left(1 - \sum_{i=1}^{p} \lambda_i\right)} x_t$$

Alternatively, in the reduced form.

$$r_t = \phi_0 + \phi_1 y_t + \phi_2 \pi_t + \phi_3 x_t + e_t \tag{7}$$

The error correction term (ECT) can be calculated from the parameter estimates ϕ_0, ϕ_1, ϕ_2 and ϕ_3 as follows.

$$\hat{e}_t = r_t - \phi_0 - \phi_1 y_t - \phi_2 \pi_t - \phi_3 x_t \tag{8}$$

Finally, the error correction model can be estimated by including the error correction term in equation 6. If the variables have no long-run relationship, equation 9 is estimated as a short-run model without the error correction term. (Huikari, 2023.)

$$r_t = \rho_0 + \sum_{i=1}^{p} \lambda_i r_{t-i} + \sum_{j=0}^{q} \eta_j y_{t-j} + \sum_{k=0}^{s} \omega_k \pi_{t-k} + \sum_{l=0}^{u} \varphi_l x_{t-l} + \varsigma \hat{e}_{t-1} \quad (9)$$

4.2 Results

Two samples are used to study whether the behaviour of a central bank changed after the global financial crisis. The first sample starts in 2000Q1 and ends in 2008Q3; the second sample starts in 2008Q4 and ends in 2021Q4. The entire sample is also analyzed but not presented as in-depth as the two subsamples.

The following section presents the main findings of the analyses for the United Kingdom, Norway, and Sweden. All the models and additional material can be found in appendices 3, 4 and 5.

4.2.1 United Kingdom

Six different models are estimated for the United Kingdom in both samples. The shadow rate (p=3) and the bank rate are dependent variables, with inflation, output gap, stock prices, and total credit to the private sector being explanatory variables. Real residential property prices are excluded from the models as they are nonstationary.

Table 6 Bounds-test results for the United Kingdom, 2000Q1-2008Q3.

Dependent variable	Explanatory variables			F-statistic		t-statistic	
UK_SHADOW3	UK_INF	UK_GAP	UK_STOCKS	11.12	***	-5.84	***
UK_SHADOW3	UK_INF	UK_GAP	UK_CREDIT	3.64		-3.09	
UK_SHADOW3	UK_INF	UK_GAP	UK_STOCKS UK_CREDIT	6.26	***	-4.28	**
UK_RATE	UK_INF	UK_GAP	UK_STOCKS	8.68	***	-5.01	***
UK_RATE	UK_INF	UK_GAP	UK_CREDIT	5.53	**	-3.74	*

UK_RATE	UK_INF	UK_GAP	UK_STOCKS UK_CREDIT	7.71	***	-4.66	***

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

F-statistic and t-statistic significance thresholds are according to Perasan et al. (2001)

All regressions include a nonrestricted constant

Table 6 shows the results of the Bounds-test used to test for cointegration between variables in the pre-crisis sample. Four of six models indicate cointegration at the 5 per cent significance level or less. We can continue estimating an ARDL model and an error correction model for these models. We continue with short-run model estimation for the models that did not indicate cointegration.

The long-run relationships in ARDL models are found in appendix 3. Only one model has a statistically significant coefficient at a 5 per cent significance level, and the coefficient is for stock prices. The coefficient is positive, and the sign is logical, but the effect is negligible. Another financial stability measure, total credit to the private sector, also has a logical sign, but the coefficient is statistically insignificant, and the effect is minimal. Every other coefficient is statistically insignificant, with varying signs and effects. The signs of inflation’s coefficients are negative and illogical, but the magnitude is similar. The sign is positive and logical for output gap coefficients with similar magnitudes.

Error correction models are presented in appendix 4. Models show similar results as the long-run relationships with financial stability measures having negligible effects on the monetary policy indicator, whether the policy or shadow rate is used. Every model has a high adjusted R-squared, over 0.84. In all error correction models, the monetary policy indicator reacts strongly and in a statistically significant way to short-term changes in inflation, but reactions to output gap vary in sign and statistical significance. However, the models' error correction terms are illogical, as they are higher than 1.

Short-run models are estimated for the models for which there was no indication of cointegration, and the models are found in appendix 5. Short-run models have worse adjusted R-squared values than error correction models, around 0.55. Short-run reactions to inflation are statistically significant and logical, but as with the error correction models, reactions to output gap vary between models. Also, reactions to financial stability measures are weak, mostly statistically insignificant, and have varying signs.

There are no significant differences between models where the dependent variable is the shadow rate and where it is the Bank rate. This is because the Bank and the shadow rates followed a similar path before the financial crisis, as seen in figure 9 in chapter 3.1.3.

Table 7 Bounds-test results for the United Kingdom, 2008Q4-2021Q4

Dependent variable	Explanatory variables			F-statistic		t-statistic	
UK_SHADOW3	UK_INF	UK_GAP	UK_STOCKS	19.40	***	-5.93	***
UK_SHADOW3	UK_INF	UK_GAP	UK_CREDIT	18.23	***	-7.40	***
UK_SHADOW3	UK_INF	UK_GAP	UK_STOCKS UK_CREDIT	20.22	***	--5.90	***
UK_RATE	UK_INF	UK_GAP	UK_STOCKS	95.14	***	-17.69	***
UK_RATE	UK_INF	UK_GAP	UK_CREDIT	94.13	***	-18.49	***
UK_RATE	UK_INF	UK_GAP	UK_STOCKS UK_CREDIT	58.07	***	-16.21	***

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

F-statistic and t-statistic significance thresholds are according to Perasan et al. (2001)

All regressions include a nonrestricted constant

In the second sample, starting in 2008Q3, all six models indicate cointegration at a 1 per cent significance level, as seen in table 7. Thus, estimating ARDL models is appropriate. The long-run relationships found in appendix 3 share similarities with the pre-crisis sample. All but one output gap's coefficients have a positive and logical sign. Contrary to the pre-crisis sample, the output gap's coefficient is statistically significant for four models at a 5 per cent significance level. Inflation, on the other hand, shows varying signs in coefficients, but none are statistically significant. All coefficients for the financial stability measures are statistically insignificant, but the effects are negligible overall. For stock prices, signs of the coefficients vary across models. On the other hand, all signs are positive and logical from model to model for the total credit to the private sector.

Error correction models show varying reactions to different variables. Models fit well with high adjusted R-squared values above 0.75 and error correction terms below 1. However, short-run reactions to inflation and the output gap are illogical and mostly statistically insignificant in all error correction models. Again, financial stability measures show weak and illogical coefficients, with some models excluding them altogether, as seen in ARDL(3,3,0,0), for example.

Due to the Bank of England's quantitative easing, the Bank and the shadow rate deviated from each other in the post-crisis sample. The deviation is visible in the long-run relationships and error correction models, as the magnitude of effects differs for each rate.

4.2.2 Norway

For Norway, four models are estimated in both samples. The policy rate is the sole dependent variable, and inflation, output gap, real residential property prices, stock prices, and total credit to the private sector are explanatory variables.

Table 8 Bounds-test results for Norway, 2000Q1-2008Q3

Dependent variable	Explanatory variables			F-statistic		t-statistic	
NOR_RATE	NOR_INF	NOR_GAP	NOR_PROPERTY	6.28	***	-3.83	**
NOR_RATE	NOR_INF	NOR_GAP	NOR_STOCKS	4.62	**	-3.60	*
NOR_RATE	NOR_INF	NOR_GAP	NOR_CREDIT	8.35	***	-3.47	*
NOR_RATE	NOR_INF	NOR_GAP	NOR_PROPERTY NOR_STOCKS NOR_CREDIT	14.82	***	-1.22	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

F-statistic and t-statistic significance thresholds are according to Perasan et al. (2001)

All regressions include a nonrestricted constant

Table 7 presents the Bounds test results in the pre-crisis sample for Norway. One out of four models estimated indicates cointegration. A long-run ARDL and error correction model are estimated for this model, and a short-run model is estimated for the rest.

In the long-run model, the signs of inflation's and the output gap's coefficients are positive and logical but statistically insignificant. On the other hand, the real residential property prices' coefficient has the wrong sign, and the effect is negligible compared to inflation and the output gap. The long-run relationships are found in appendix 3.

The error correction model shows illogical, although statistically significant, short-run reactions to inflation and the output gap. Reaction to real residential property prices has varying signs, small coefficients and are statistically insignificant. Adjusted R-squared is high, 0.86, and the error correction term is logical.

Reactions in short-run models are similar to the error correction model. Reactions to inflation and the output gap have varying signs and are statistically insignificant. Again, reactions to financial stability measures are weak and statistically insignificant. Adjusted R-squared values are low, 0.58 and 0.59. We could not estimate a short-run model with all the financial stability measures due to the sample size and lack of degrees of freedom.

Moving to the post-crisis sample, all models estimated indicate cointegration at a 1 per cent significance level, as seen in table 9. The long-run relationships, found in appendix 3, show illogical relationships. The inflation and output gap coefficients are primarily negative and statistically insignificant. Three out of four models have at least one significant financial stability measure, but signs are primarily illogical, and effects close to zero. The results differ from the pre-crisis sample, where coefficients for inflation and the output gap have correct signs. On the other hand, the coefficients for financial stability measures show little to no effects in both samples, indicating that Norges bank does not react to them.

Table 9 Bounds-test results for Norway, 2008Q4-2021Q4

Dependent variable	Explanatory variables			F-statistic		t-statistic	
NOR_RATE	NOR_INF	NOR_GAP	NOR_PROPERTY	27.98	***	-8.93	***
NOR_RATE	NOR_INF	NOR_GAP	NOR_STOCKS	11.97	***	-5.92	***
NOR_RATE	NOR_INF	NOR_GAP	NOR_CREDIT	40.93	***	-11.75	***

NOR_RATE	NOR_INF	NOR_GAP	NOR_PROPERTY NOR_STOCKS NOR_CREDIT	25.15	***	-9.04	***

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

F-statistic and t-statistic significance thresholds are according to Perasan et al. (2001)

All regressions include a nonrestricted constant

For the post-crisis sample, error correction models also show varying short-term results. The policy rates' reaction to inflation and the output gap have varying signs, and most coefficients are statistically insignificant. Financial stability measures show a weak effect, with property prices having only statistically significant coefficients. Adjusted R-squared values are high, over 0.81, and the error correction term is logical and has a similar magnitude in all models.

4.2.3 Sweden

For Sweden, six models in total are estimated in both samples. The policy and the shadow rate (p=3) are dependent variables; inflation, output gap, real residential property prices, and stock prices are explanatory variables.

Table 10 Bounds-test results for Sweden, 2000Q1-2008Q3

Dependent variable	Explanatory variables			F-statistic		t-statistic	
SWE_SHADOW3	SWE_INF	SWE_GAP	SWE_PROPERTY	10.29	***	-5.22	***
SWE_SHADOW3	SWE_INF	SWE_GAP	SWE_STOCKS	5.59	**	-1.80	
SWE_SHADOW3	SWE_INF	SWE_GAP	SWE_PROPERTY SWE_STOCKS	5.57	***	-3.78	*
SWE_RATE	SWE_INF	SWE_GAP	SWE_PROPERTY	8.66	***	-4.74	***
SWE_RATE	SWE_INF	SWE_GAP	SWE_STOCKS	5.00	**	-1.91	
SWE_RATE	SWE_INF	SWE_GAP	SWE_PROPERTY SWE_STOCKS	8.67	***	-5.30	***

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

F-statistic and t-statistic significance thresholds are according to Perasan et al. (2001)

All regressions include a nonrestricted constant

Table 9 shows the results of the Bounds-tests for the models in the pre-crisis sample. Three out of six models indicate cointegration at a 1 per cent significance level, and estimating a long-run and error correction model is appropriate. Short-run models are estimated for the three models for which cointegration cannot be confirmed.

The long-run relationships in appendix 3 show statistically significant and logical coefficients for inflation and the output gap in the pre-crisis sample. Also, the coefficient for real residential property prices is statistically significant at a 1 per cent significance level in all models. The stock prices' coefficient is not statistically significant, and overall, the financial stability measure's effects are marginal.

Error correction models show varying short-run effects when compared to long-run relationships. Monetary policy indicators' reaction to inflation and the output gap varies in sign and statistical significance between models, but the reaction to current inflation is highly statistically significant and has a correct sign. Reactions to financial stability measures are weak, with property prices having positive signs and stock prices having negative signs. Error correction terms are under 1, except for the model with all financial stability measures. Adjusted R-squared values range between 0.70 and 0.90.

Short-run models show positive reactions to inflation and the output gap. However, reactions to financial stability measures vary in signs and are statistically insignificant. Also, the reactions are negligible. Adjusted R-squared values are also low, around 0.50.

Three models indicate cointegration at a 1 per cent significance level in the post-crisis sample, as seen in table 11. However, the long-run relationships differ from the pre-crisis sample. The inflation and output gap coefficients have varying signs and are statistically insignificant in most models. On the other hand, the real residential property prices' coefficient has similar behaviour in both samples, as it is negative and statistically significant at a 1 per cent significance level. Stock prices' coefficient is statistically significant and has a correct sign in the post-crisis sample, but monetary policy's reaction to financial stability measures is as marginal as in the pre-crisis sample.

Table 11 Bounds-test results for Sweden, 2008Q4-2021Q4

Dependent variable	Explanatory variables			F-statistic		t-statistic	
SWE_SHADOW3	SWE_INF	SWE_GAP	SWE_PROPERTY	9.57	***	-4.86	***
SWE_SHADOW3	SWE_INF	SWE_GAP	SWE_STOCKS	9.30	***	-3.41	
SWE_SHADOW3	SWE_INF	SWE_GAP	SWE_PROPERTY SWE_STOCKS	23.09	***	-9.07	***
SWE_RATE	SWE_INF	SWE_GAP	SWE_PROPERTY	11.19	***	-5.14	***
SWE_RATE	SWE_INF	SWE_GAP	SWE_STOCKS	10.76	***	-3.74	*
SWE_RATE	SWE_INF	SWE_GAP	SWE_PROPERTY SWE_STOCKS	18.48	***	-7.55	***

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance
F-statistic and t-statistic significance thresholds are according to Perasan et al. (2001)
All regressions include a nonrestricted constant

Error correction models have logical error correction terms of less than one and adjusted R-squared values ranging from 0.70 to 0.87. Akaike information criterion excludes all variables except the shadow rate from one model (ARDL(4,0,0,0,0)), making interpretation meaningless. Rest three models show illogical but statistically significant reactions to inflation. Reaction to the output gap is logical in ARDL(4,3,2,2), but other models exclude it altogether. Reaction to property prices is negative for all models, and the effect is weak. For stock prices, no reaction can be established as optimal models based on the lowest Akaike information criterion exclude them

Short-run models are estimated for the models with stock prices as the sole financial stability measure. Monetary policy indicators' reactions to inflation vary in sign and statistical significance. Also, the magnitude is negligible. The output gap, on the other hand, has positive and statistically significant coefficients. The coefficients for stock prices are illogical and statistically insignificant

Models with the shadow rate as the dependent variable do not differ significantly from models where the policy rate is the dependent variable. In the pre-crisis sample, this is expected as the shadow and policy rates are nearly identical. However, we should see differences in the post-crisis sample, as quantitative easing causes the shadow rate to deviate from the policy rate.

4.3 Discussion

Overall, no definitive conclusions can be based on the results. In the long run, the ARDL model works best for Norway and Sweden in the pre-crisis sample. Coefficients for inflation and the output gap are positive and statistically significant, indicating that monetary policy tightens when either inflation or the output gap increase. For the United Kingdom, coefficients for inflation and the output gap are illogical and statistically insignificant, indicating that the model is not performing well. In the post-crisis sample, coefficients for the output gap in the United Kingdom are positive and statistically significant, with inflation having varying and statistically insignificant coefficients. Norway and Sweden have no statistically significant coefficients for inflation and the output gap in the post-crisis sample, indicating that the Taylor rule cannot explain monetary policy reactions to inflation and the output gap, at least in our model.

In the long run, our model shows that financial stability measures have insignificant effects on monetary policy. Across all countries, samples, and models, no significant effect is found, and coefficients are primarily statistically insignificant. Thus, we cannot reject that the long-run effect is zero.

Depending on the country, error correction and short-run models show varying results. For the United Kingdom, models show that monetary policy’s reactions to inflation are logical and statistically significant in the short run, but reactions to the output gap are statistically insignificant. Models considering Norway and Sweden show varying short-run reactions to inflation and the output gap, with most coefficients being statistically insignificant.

In the short run financial stability measures have negligible effects on monetary policy. This result is the same in each sample and all three countries. However, no clear conclusion can be made based on the results, as most coefficients are statistically insignificant in our models.

To conclude the results, our model indicates that the three central banks studied, the Bank of England, Norges Bank and Sveriges Riksbank, do not significantly react to financial stability measures. The result is the same for pre-crisis and post-crisis samples. Additionally, results do not change significantly when the estimation is done for the whole sample. The result is also robust when inflation is replaced with core inflation in the ARDL model.

Especially in the pre-crisis sample, a small sample size of 35 observations can affect the model's performance. Post-crisis sample does not have this issue, as there are 53 observations. The sample size could be increased by including the 1990s and 2022. This would solve the small sample size issue but introduce other problems, such as the Nordic crises and inflation's erratic behaviour in 2022. Using monthly frequency instead of quarterly would also increase the sample size, but finding monthly data on variables, especially the output gap, proved difficult.

Also, the choice of variables could affect the model's performance. In the Taylor rule, we use historical data for all our variables. However, central banks use expected or forecasted values of inflation and the output gap in addition to historical data to adjust monetary policy accordingly. It would also be logical that if a central bank reacts to financial stability measures, it will react to expected future developments. Additionally, the monetary policy of foreign central banks can influence the monetary policy of the domestic central bank. Especially the Federal Reserve and the European Central Bank can influence surrounding central banks (see, for example, Harju (2021) for further details), but this effect is excluded from our model.

Even though our model suggests that central banks do not react to financial stability when setting monetary policy, we cannot entirely dismiss it. First, monetary policy, especially the policy rate, is a blunt tool that cannot easily be targeted. Thus, it is hard to distinguish reactions to different variables. Second, central banks do not set monetary policy by looking solely at one policy rule created in the 90s. They look at multiple data streams, including forecasts, specialist reports, and macroeconomic models, and most likely financial stability issues are included in the stream. In the end, however, monetary policy decisions are based on judgement.

5 CONCLUSIONS

This thesis studied whether monetary policy reacts to financial stability measures. The study was conducted by estimating an ARDL model based on a Taylor rule augmented with financial stability measures. The estimations were done for three central banks separately; the Bank of England, Norges Bank and Sveriges Riksbank were chosen for the study.

The first part of the thesis laid the foundations for the empirical section by discussing the basics of monetary policy, objectives and instruments and providing a literature review on financial stability and its relationship with monetary policy. Literature on the relationship provides differing results, and no definitive conclusions can be drawn on the relationship between monetary policy and financial stability. Empirical studies find that monetary policy affects financial stability, primarily through stock and property prices, but the effects are minor.

In the second part, the Taylor rule and its extensions were discussed. In the celebrated Taylor rule, the central bank's policy rate reacts to inflation and the output gap. Over the years, the Taylor rule has been extended with various variables, and in our study, we augment the Taylor rule with financial stability measures; stock prices, real residential property prices and total credit to the non-financial private sector are chosen as measures. From 2000 to 2021, inflation and core inflation remained around the two per cent inflation target, with inflation being more volatile than core inflation. The output gap remained stable, excluding the global financial crisis and the beginning of the Covid-19 pandemic, where the gap widened momentarily.

For financial stability measures, developments were similar across countries. Stock prices increased steadily before a significant drop during the global financial crisis. Afterwards, stock prices increased steadily, with the beginning of the Covid-19 pandemic causing a momentary disruption. Real residential housing prices followed a similar pattern, with steady increases before and after the global financial crisis and a significant drop during the crisis. Total credit to the non-financial private sector as a percentage of GDP increased quickly before the global financial crisis, but the growth was modest afterwards in Norway and Sweden and stalled in the United Kingdom.

The third part of the thesis consisted of forming the econometric model and estimating it for the chosen central banks separately. The autoregressive distributed lag model was chosen as it can capture long-run relationships well. The global financial crisis presents a noticeable regime change, and thus we split the sample into two; 2000Q1 to 2008Q3 and 2008Q4 to 2021Q4. In all models, the monetary policy indicator, either the policy or the shadow rate, is the dependent variable and inflation, the output gap, and a combination of financial stability measures are explanatory variables. Financial stability measures include stock prices, real residential housing prices, and total credit to the non-financial private sector.

We find no significant reaction of monetary policy to financial stability measures. The result is robust across countries, samples and models with different variables. Additionally, reactions to inflation and the output gap vary, indicating that the performance of models is not perfect. In the long run, models perform the best in the pre-crisis sample in Norway and Sweden. In the short run, on the other hand, models perform the best in the United Kingdom. Financial stability measures have insignificant and varying coefficients in the long and short run, a result in line with most of the literature.

The model could be improved in many ways. First, central banks are forward-looking and using forecasts of inflation and the output gap in addition to historical data could improve the model performance. Also, forecasts of financial stability measures could be used. Second, finding a monthly proxy for real GDP and using monthly data for estimations could improve the performance. We found no good proxies, but this could change as new measures are developed. Additionally, our model does not consider the monetary policy of the Federal Reserve and the European Central Bank, which influence smaller central banks' monetary policies.

Monetary policy has nonlinearities, which are impossible to capture with a linear model. Switching to a nonlinear ARDL model instead of a standard ARDL model could improve the model as it could capture the asymmetric reactions of monetary policy to different variables, for example, inflation. Nonlinear ARDL with revised variables is a logical continuation of this thesis and could be pursued in a future study.

In addition to econometric studies, a deeper literature review on financial stability issues, including the most recent theoretical and empirical studies, would contribute towards a consensus and coherent theory. For example, the empirical studies discussed in this thesis primarily focus on the Federal Reserve and the United States, and it would be interesting to study other areas, such as the eurozone. To our knowledge, no literature review on financial stability issues has been written from Europe’s point of view at the time of writing this thesis.

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APPENDICES

Appendix 1 Variable definitions

Variable	Name
NOR_CORE	Core inflation in Norway
NOR_CREDIT	Total credit to the private sector in Norway
NOR_GAP	The output gap in Norway
NOR_INF	Inflation in Norway
NOR_PROPERTY	Property prices in Norway
NOR_RATE	The policy rate in Norway
NOR_STOCKS	Stock prices in Norway
SWE_CORE	Core inflation in Sweden
SWE_CREDIT	Total credit to the private sector in Sweden
SWE_GAP	The output gap in Sweden
SWE_INF	Inflation in Sweden
SWE_PROPERTY	Property prices in Sweden
SWE_RATE	The policy rate in Sweden
SWE_SHADOW2	The Shadow rate in Sweden, pricing factor equals two
SWE_SHADOW3	The Shadow rate in Sweden, pricing factor equals three
SWE_STOCKS	Stock prices in Sweden
UK_CORE	Core inflation in the United Kingdom
UK_CREDIT	Total credit to the private sector in the United Kingdom
UK_GAP	The output gap in the United Kingdom
UK_INF	Inflation in the United Kingdom
UK_PROPERTY	Property prices in the United Kingdom
UK_RATE	The policy rate in the United Kingdom
UK_SHADOW2	The Shadow rate in the United Kingdom, pricing factor equals two
UK_SHADOW3	The Shadow rate in the United Kingdom, pricing factor equals three
UK_STOCKS	Stock prices in the United Kingdom

Appendix 2 ADF unit root tests

The whole period, 2000Q1 to 2021Q4

	Level				First Difference			
	Constant		Constant and Trend		Constant		Constant and Trend	
NOR_CORE	0.3082		0.1033		0.0000	***	0.0000	***
NOR_CREDIT	0.2434		0.1809		0.0220	**	0.0698	*
NOR_GAP	0.0000	***	0.0004	***	0.0000	***	0.0000	***
NOR_INF	0.1671		0.0579	*	0.0000	***	0.0000	***
NOR_PROPERTY	0.8035		0.1499		0.0043	***	0.0181	**
NOR_RATE	0.2400		0.0483	**	0.0002	***	0.0015	***
NOR_STOCKS	0.9989		0.7318		0.0000	***	0.0000	***
SWE_CORE	0.0000	***	0.0001	***	0.0000	***	0.0004	***
SWE_CREDIT	0.9017		0.1511		0.0271	**	0.1078	
SWE_GAP	0.0026	***	0.0151	**	0.0001	***	0.0000	***
SWE_INF	0.0139	**	0.0666	*	0.0000	***	0.0000	***
SWE_PROPERTY	0.9504		0.0410	**	0.0052	***	0.0260	**
SWE_RATE	0.2277		0.0140	***	0.0000	***	0.0004	***
SWE_SHADOW2	0.3403		0.0115	***	0.0000	***	0.0001	***
SWE_SHADOW3	0.3376		0.0300	**	0.0001	***	0.0005	***
SWE_STOCKS	0.9981		0.8151		0.0000	***	0.0000	***
UK_CORE	0.4579		0.1724		0.0000	***	0.0002	***
UK_CREDIT	0.1424		0.6340		0.0000	***	0.0000	***
UK_GAP	0.0000	***	0.0000	***	0.0001	***	0.0000	***
UK_INF	0.1468		0.2505		0.0014	***	0.0133	**
UK_PROPERTY	0.2103		0.1211		0.0965	*	0.3154	
UK_RATE	0.2994		0.2141		0.0047	***	0.0210	**
UK_SHADOW2	0.4870		0.3974		0.0060	***	0.0268	**
UK_SHADOW3	0.4178		0.4459		0.0000	***	0.0002	***
UK_STOCKS	0.3414		0.0438	**	0.0000	***	0.0000	***

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Sample from 2000Q1 to 2008Q3

	Level				First Difference			
	Constant		Constant and Trend		Constant		Constant and Trend	
NOR_CORE	0.6873		0.9606		0.0001	***	0.0004	***
NOR_CREDIT	0.9916		0.0296	**	0.0003	***	0.0016	***
NOR_GAP	0.0569	*	0.0199	**	0.0000	***	0.0000	***
NOR_INF	0.1865		0.5413		0.0000	***	0.0002	***
NOR_PROPERTY	0.9845		0.0994	*	0.1053		0.2219	
NOR_RATE	0.4209		0.8310		0.1155		0.2652	
NOR_STOCKS	0.8204		0.4287		0.1939		0.4782	
SWE_CORE	0.0375	**	0.9128		0.0048	***	0.0250	**
SWE_CREDIT	1.0000		1.0000		0.6702		0.5713	
SWE_GAP	0.6394		0.7562		0.0000	***	0.0000	***
SWE_INF	0.9310		0.9818		0.0002	***	0.0009	***
SWE_PROPERTY	0.9076		0.7788		0.0007	***	0.0043	**
SWE_RATE	0.7313		0.9866		0.0302	**	0.0433	**
SWE_SHADOW2	0.3877		0.9084		0.0265	**	0.0335	**
SWE_SHADOW3	0.3728		0.9117		0.0211	**	0.0398	**
SWE_STOCKS	0.3054		0.2314		0.0609	*	0.2133	
UK_CORE	0.5416		0.4613		0.0000	***	0.0003	***
UK_CREDIT	0.5766		0.2648		0.0003	***	0.0016	***
UK_GAP	0.0286	**	0.0471	**	0.2064		0.7477	
UK_INF	0.9978		0.9859		0.0207	**	0.0404	**
UK_PROPERTY	0.4452		0.9950		0.9183		0.9533	
UK_RATE	0.0820	*	0.2219		0.0752	*	0.1584	
UK_SHADOW2	0.1350		0.2880		0.0193	**	0.0423	**
UK_SHADOW3	0.1001		0.2042		0.0769	*	0.1574	
UK_STOCKS	0.1559		0.2645		0.2945		0.6105	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Sample from 2008Q4 to 2021Q4

	Level				First Difference			
	Constant		Constant and Trend		Constant		Constant and Trend	
NOR_CORE	0.4970		0.4574		0.0000	***	0.0003	***
NOR_CREDIT	0.0256	**	0.0029	***	0.5036		0.7524	
NOR_GAP	0.0015	***	0.0055	***	0.0000	***	0.0000	***
NOR_INF	0.4528		0.3645		0.0000	***	0.0000	***
NOR_PROPERTY	0.8133		0.3883		0.0094	***	0.0460	**
NOR_RATE	0.0000	***	0.0000	**	0.0001	***	0.0002	***
NOR_STOCKS	0.9831		0.0604	*	0.0001	***	0.0002	***
SWE_CORE	0.0002	***	0.0004	***	0.0006	***	0.0026	***
SWE_CREDIT	0.8878		0.0430	**	0.0000	**	0.0000	***
SWE_GAP	0.0070	***	0.0161	**	0.0000	***	0.0000	***
SWE_INF	0.0112	**	0.0219	**	0.0016	***	0.0530	*
SWE_PROPERTY	0.8870		0.2441	**	0.0377	**	0.1514	
SWE_RATE	0.0000	***	0.0000	***	0.0005	***	0.0007	***
SWE_SHADOW2	0.0003	***	0.0001	***	0.0002	***	0.0003	***
SWE_SHADOW3	0.0003	***	0.0004	**	0.0038	***	0.0085	***
SWE_STOCKS	0.9999		0.8877		0.0000	***	0.0001	***
UK_CORE	0.4908		0.7740		0.0281	**	0.0660	*
UK_CREDIT	0.5596		0.4828		0.0001	***	0.0008	***
UK_GAP	0.0004	***	0.0019	***	0.0000	***	0.0000	***
UK_INF	0.1347		0.6938		0.0103	**	0.0191	**
UK_PROPERTY	0.8873		0.6198		0.0196	*	0.1442	
UK_RATE	0.0000	***	0.0000	***	0.0795	*	0.1193	
UK_SHADOW2	0.0000	***	0.0000	***	0.0553	*	0.0001	***
UK_SHADOW3	0.0000	***	0.0000	***	0.0016	***	0.0004	***
UK_STOCKS	0.2217		0.0434	**	0.0001	***	0.0007	***

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Appendix 3 Long-run relationships in ARDL-models

United Kingdom, 2000Q1-2008Q3

Long-run relationships in ARDL-models									
UK_SHADOW3 =	-0.4735	UK_INF	11.3448	UK_GAP	0.0443	UK_STOCKS			
	(0.1403)		(9.0800)		(0.0044)				
UK_SHADOW3=	-0.8569	UK_INF	4.9421	UK_GAP	0.0540*	UK_STOCKS	0.0128	UK_CREDIT	
	(1.0130)		(20.4641)		(0.0227)		(0.0411)		
UK_RATE=	-0.4735	UK_INF	11.3448	UK_GAP	0.0443	UK_STOCKS			
	(0.1403)		(9.0800)		(0.0044)				
UK_RATE=	-0.6686	UK_INF	6.8289	UK_GAP	0.0487***	UK_STOCKS	0.0026	UK_CREDIT	
	(0.5611)		(6.9914)		(0.0099)		(0.02155)		

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

All regressions include a nonrestricted constant. Standard error in parenthesis

United Kingdom, 2008Q3-2021Q4

Long-run relationships in ARDL-models								
UK_SHADOW3 =	0.3529*	UK_INF	14.3396	UK_GAP	-0.5000	UK_STOCKS		
	(0.2077)		(8.8676)		(0.0222)			
UK_SHADOW3 =	-0.223	UK_INF	25.9147**	UK_GAP	0.0466*	UK_CREDIT		
	(0.1678)		(11.6580)		(0.0260)			
UK_SHADOW3=	-0.2236	UK_INF	-0.4786	UK_GAP	0.0621	UK_STOCKS	0.0067	UK_CREDIT
	(0.2054)		(12.4352)		(0.0375)		(0.0396)	
UK_RATE=	0.059	UK_INF	5.3385**	UK_GAP	-0.0042	UK_STOCKS		
	(0.0420)		(2.0234)		(0.0039)			
UK_RATE=	0.0426	UK_INF	5.5313**	UK_GAP	0.0058	UK_CREDIT		
	(0.0549)		(2.4308)		(0.0068)			
UK_RATE=	-0.0079	UK_INF	9.9312***	UK_GAP	-0.0062	UK_STOCKS	0.0066	UK_CREDIT
	(0.0639)		(3.2443)		(0.0056)		(0.0096)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

All regressions include a nonrestricted constant. Standard error in parenthesis

Norway, 2000Q1-2008Q3

Long-run relationships in ARDL-models						
NOR_RATE=	0.8111	NOR_INF	266.9183*	NOR_GAP	-0.0954	NOR_PROPERTY
	(0.5582)		(134.7509)		(0.0520)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

All regressions include a nonrestricted constant. Standard error in parenthesis

Norway, 2008Q4-2021Q4

Long-run relationships in ARDL-models										
NOR_RATE=	-0.2042**	NOR_INF	6.2823	NOR_GAP	-0.0245***	NOR_PROPERTY				
	(0.0934)		(6.8028)		(0.0038)					
NOR_RATE=	-0.2063	NOR_INF	-22.2930*	NOR_GAP	-0.0018*	NOR_STOCKS				
	(0.1664)		(11.2759)		(0.0010)					
NOR_RATE=	-0.0670	NOR_INF	-20.8420**	NOR_GAP	-0.0329***	NOR_CREDIT				
	(0.1079)		(7.7718)		(0.0042)					
NOR_RATE=	-0.1737*	NOR_INF	-13.8483	NOR_GAP	-0.0192**	NOR_PROPERTY	0.0016*	NOR_STOCKS	-0.0202**	NOR_CREDIT
	(0.0924)		(9.4274)		(0.0089)		(0.0008)		(0.0075)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

All regressions include a nonrestricted constant. Standard error in parenthesis

Sweden, 2000Q1-2008Q3

Long-run relationships in ARDL-models									
SWE_SHADOW3 =	0.9799***	SWE_INF	36.0682***	SWE_GAP	-0.0085***	SWE_PROPERTY		
	(0.0752)		(7.9680)		(0.0035)			
SWE_RATE=	0.9606***	SWE_INF	36.8274***	SWE_GAP	-0.0288***	SWE_PROPERTY		
	(0.0833)		(8.9163)		(0.0038)			
SWE_RATE=	0.8992***	SWE_INF	16.1535	SWE_GAP	-0.0175***	SWE_PROPERTY	0.0067	SWE_STOCKS
	(0.0610)		(9.1067)		(0.0024)		(0,0048)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

All regressions include a nonrestricted constant. Standard error in parenthesis

Swedem, 2008Q4-2021Q4

Long-run relationships in ARDL-models								
SWE_SHADOW3 =	0.2327	SWE_INF	2.3826	SWE_GAP	-0.0234***	SWE_PROPERTY		
	(0.1674)		(11.8313)		(0.0026)			
SWE_SHADOW3=	-0.0291	SWE_INF	3.722	SWE_GAP	-0.0414***	SWE_PROPERTY	0.0196***	SWE_STOCKS
	(0.0741)		(6.1677)		(0.0035)		(0.0029)	
SWE_RATE=	0.3314***	SWE_INF	-5.7122	SWE_GAP	-0.0181***	SWE_PROPERTY		
	(0.1179)		(9.2766)		(0.0018)			
SWE_RATE=	0.2255**	SWE_INF	-5.9914	SWE_GAP	-0.0273***	SWE_PROPERTY	0.0100***	SWE_STOCKS
	(0.0806)		(5.8805)		(0.0026)		(0.0024)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

All regressions include a nonrestricted constant. Standard error in parenthesis

Appendix 4 Error correction models

United Kingdom, 2000Q1-2008Q3

Explanatory variable	Dependent Variable ΔUK_SHADOW3		ΔUK_SHADOW3		ΔUK_RATE		ΔUK_RATE	
ΔUK_SHADOW3(-1)	0.6756***	(0.1172)	0.8404***	(0.1428)				
ΔUK_SHADOW3(-2)	0.4235**	(0.1454)	0.3892*	(0.1763)				
ΔUK_SHADOW3(-3)	0.9693***	(0.2191)	0.9687***	(0.2179)				
ΔUK_RATE(-1)					0.6602***	(0.1225)	0.7847***	(0.1231)
ΔUK_RATE(-2)					0.4711***	(0.1460)	0.4929***	(0.1326)
ΔUK_RATE(-3)					0.8235***	(0.2320)	0.9608***	(0.2327)
ΔUK_INF	0.1383	(0.0967)	0.1471	(0.1177)	0.0428	(0.0978)	0.1368***	(0.0831)
ΔUK_INF(-1)	0.4616***	(0.1141)	1.0088***	(0.1873)	0.5472***	(0.1214)	0.8996***	(0.1462)
ΔUK_INF(-2)	0.5596***	(0.1556)	1.0487***	(0.2161)	0.6121***	(0.1611)	1.0310***	(0.1872)
ΔUK_INF(-3)	0.4659***	(0.1293)	0.6861***	(0.1464)	0.5538***	(0.1437)	0.7364***	(0.1395)
ΔUK_GAP	2.2303	(8.9254)	1.3463	(11.0018)	2.6563	(9.0380)		
ΔUK_GAP(-1)	-19.7504*	(10.207)	-4.6140	(11.0605)	-15.5885	(10.1239)		
ΔUK_GAP(-2)	11.5374	(9.8933)	17.5036	(10.4233)	8.2269	(10.4535)		
ΔUK_GAP(-3)	-23.1481**	(9.1373)	-17.7756*	(9.0168)	-19.2645*	(9.4737)		
ΔUK_STOCKS	-0.0090	(0.0063)	-0.0013**	(0.0088)	-0.0105	(0.0065)	-0.0067	(0.0081)
ΔUK_STOCKS(-1)	-0.0108	(0.0065)	-0.0295	(0.0120)	-0.0158*	(0.0073)	-0.0338***	(0.0093)
ΔUK_STOCKS(-2)	0.0015	(0.0057)	-0.0149	(0.0100)	-0.0031	(0.0064)	-0.0183*	(0.0084)
ΔUK_STOCKS(-3)	-0.0145**	(0.0064)	-0.0235*	(0.0107)	-0.0151**	(0.0067)	-0.0190**	(0.0083)
ΔUK_CREDIT			0.0231	(0.0259)			0.0279	(0.0211)
ΔUK_CREDIT(-1)			-0.0276	(0.0296)			-0.0204	(0.0205)
ΔUK_CREDIT(-2)			-0.0025	(0.0179)			0.0063	(0.0170)
ΔUK_CREDIT(-3)			-0.0509*	(0.0215)			-0.0479**	(0.0174)
ECT(-1)	-1.1569***	(0.1538)	-1.3366***	(0.1850)	-1.1569***	(0.1741)	-1.4143***	(0.1925)
Constant	1.846***	(0.2443)	-0.8435***	(0.1505)	1.9555***	(0.2943)	1.5878***	(0.2074)
Adjusted R-squared	0.8570		0.8609		0.8404		0.8586	
Model	ARDL(4,4,4,4)		ARDL(4,4,4,4,4)		ARDL(4,4,4,4)		ARDL(4,4,0,4,4)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

United Kingdom, 2008Q4-2021Q4

	Dependent Variable											
Explanatory variable	ΔUK_SHADOW3		ΔUK_SHADOW3		ΔUK_SHADOW3		ΔUK_RATE		ΔUK_RATE		ΔUK_RATE	
ΔUK_SHADOW3(-1)	0.2570***	(0.0876)	0.3402***	(0.0884)	0.2661	(0.0879)						
ΔUK_SHADOW3(-2)	-0.1798**	(0.0829)	-0.2821***	(0.0832)	-0.3837	(0.0750)						
ΔUK_SHADOW3(-3)												
ΔUK_RATE(-1)							0.4783***	(0.0439)	0.4748***	(0.0442)	0.5441***	(0.0498)
ΔUK_RATE(-2)							-0.2634***	(0.0493)	-0.2709***	(0.0494)	-0.2871***	(0.0499)
ΔUK_RATE(-3)							0.1277***	(0.0400)	0.1394***	(0.0400)	0.1351***	(0.0412)
ΔUK_INF	0.1592	(0.1004)					-0.0441	(0.0325)	-0.0472	(0.0327)	-0.0559	(0.0344)
ΔUK_INF(-1)	-0.0985	(0.1173)					0.0635	(0.0381)	0.0612	(0.0383)	0.0774**	(0.0377)
ΔUK_INF(-2)	-0.3001***	(0.1094)					-0.1561***	(0.0332)	-0.1533***	(0.0334)	-0.1748***	(0.0377)
ΔUK_INF(-3)											0.0670*	(0.0384)
ΔUK_GAP			8.2033***	(2.5204)			0.9991	(0.6979)	0.8538	(0.7020)	3.0975***	(0.9114)
ΔUK_GAP(-1)			-2.9472	(1.9905)			-1.9913***	(0.4503)	-2.0815***	(0.4534)	-2.5785***	(0.6597)
ΔUK_GAP(-2)			-2.6669*	(1.5806)							-0.4119	(0.5360)
ΔUK_GAP(-3)			-3.6401***	(1.1336)							-1.0155***	(0.3508)
ΔUK_STOCKS												
ΔUK_STOCKS(-1)												
ΔUK_STOCKS(-2)												
ΔUK_STOCKS(-3)												
ΔUK_CREDIT			-0.0512**	(0.0190)	-0.0336	(0.0170)					-0.0084	(0.0066)
ΔUK_CREDIT(-1)			-0.0537***	(0.0189)	-0.0374	(0.0149)						
ΔUK_CREDIT(-2)			0.0028	(0.0168)	-0.0100	(0.0157)						
ΔUK_CREDIT(-3)			-0.0509***	(0.0173)	-0.0667	(0.0145)						
ECT(-1)	-0.3228***	(0.0354)	-0.3167***	(0.0357)	-0.2598	(0.0246)	-0.4205***	(0.0208)	-0.4152***	(0.0206)	-0.4077***	(0.0226)
GAP_DUMMY	0.3499	(0.3163)	1.8457***	(0.6472)	0.0660	(0.2869)	-0.384**	(0.1891)	-0.4159**	(0.1904)	0.1507	(0.2224)
Constant	-0.7305***	(0.0810)	-3.0525***	(0.3184)	-5.0136	(0.4620)	0.3384***	(0.0224)	-0.2293***	(0.0157)	0.0056	(0.0131)
Adjusted R-squared	0.7754		0.8522		0.8574		0.9600		0.9594		0.9623	
Model	ARDL(3,3,0,0)		ARDL(3,0,4,4)		ARDL(3,0,0,0,4)		ARDL(4,3,2,0)		ARDL(4,3,2,0)		ARDL(4,4,4,0,1)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Norway, 2000Q1-2008Q3

Explanatory variable	Dependent Variable ΔNOR_RATE	
ΔNOR_RATE(-1)	0.5371***	(0.1628)
ΔNOR_RATE(-2)	0.3840**	(0.1719)
ΔNOR_RATE(-3)	-0.2298	(0.1480)
ΔNOR_INF	-0.1996**	(0.0860)
ΔNOR_INF(-1)	-0.0376	(0.0704)
ΔNOR_INF(-2)	-0.3072***	(0.0659)
ΔNOR_INF(-3)	-0.3390***	(0.0810)
ΔNOR_GAP	13.4158**	(5.4553)
ΔNOR_GAP(-1)	-31.3151**	(10.3669)
ΔNOR_GAP(-2)	-45.2971***	(9.0806)
ΔNOR_GAP(-3)	-14.8506*	(6.8113)
ΔNOR_PROPERTY	-0.0290*	(0.0153)
ΔNOR_PROPERTY(-1)	0.0081	(0.0140)
ΔNOR_PROPERTY(-2)	0.0203	(0.0136)
ΔNOR_PROPERTY(-3)	-0.0558***	(0.0146)
ECT(-1)	-0.2053***	(0.0363)
Constant	3.4794***	(0.6109)
Adjusted R-squared	0.8565	
Model	ARDL(4,4,4,4)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Norway, 2008Q4-2021Q4

	Dependent Variable							
Explanatory variable	ΔNOR_RATE		ΔNOR_RATE		ΔNOR_RATE		ΔNOR_RATE	
ΔNOR_RATE(-1)	0.5342***	(0.0518)	0.4138***	(0.0817)	0.4784***	(0.0573)	0.3995***	
ΔNOR_RATE(-2)							0.0892	
ΔNOR_RATE(-3)								
ΔNOR_INF	-0.0605*	(0.0358)	-0.0305	(0.0444)	-0.0626	(0.0385)	-0.0947***	(0.0325)
ΔNOR_INF(-1)	0.0091	(0.0316)	-0.0407	(0.0402)	0.0131	(0.0337)	0.0329	(0.0277)
ΔNOR_INF(-2)	-0.0487	(0.0312)	-0.0805*	(0.0398)	-0.1181***	(0.0311)	-0.0852***	(0.0260)
ΔNOR_INF(-3)	0.1218***	(0.0339)	0.1049**	(0.0418)	0.0611*	(0.0325)	0.0979***	(0.0271)
ΔNOR_GAP					-3.5801	(2.2895)	-3.7484*	(1.8881)
ΔNOR_GAP(-1)					-2.1259	(1.8024)	-1.1470	(1.5105)
ΔNOR_GAP(-2)					-0.1960	(1.9028)	-0.2768	(1.6333)
ΔNOR_GAP(-3)					-4.9784***	(1.7066)	-5.1384***	(1.4440)
ΔNOR_PROPERTY	-0.0174***	(0.0046)					-0.0131***	(0.0037)
ΔNOR_PROPERTY(-1)	0.0141***	(0.0046)					0.0145***	(0.0037)
ΔNOR_PROPERTY(-2)								
ΔNOR_PROPERTY(-3)								
ΔNOR_STOCKS			-0.0021	(0.0013)			-0.0017*	(0.0009)
ΔNOR_STOCKS(-1)			0.0017	(0.0012)				
ΔNOR_STOCKS(-2)			0.0019	(0.0012)				
ΔNOR_STOCKS(-3)								
ΔNOR_CREDIT								
ΔNOR_CREDIT(-1)								
ΔNOR_CREDIT(-2)								
ΔNOR_CREDIT(-3)								
ECT(-1)	-0.3893***	(0.0355)	-0.2953***	(0.0411)	-0.3677***	(0.0277)	-0.4423***	(0.0335)
GAP_DUMMY	-1.0035***	(0.1467)	-1.4836***	(0.2178)	-0.9324***	(0.1941)	-1.1033***	(0.1631)
Constant	2.8143***	(0.2625)	0.9516***	(0.1505)	3.7072***	(0.2819)	4.5767***	(0.3534)
Adjusted R-squared	0.8813		0.8151		0.8887		0.9286	
Model	ARDL(2,4,0,2)		ARDL(2,4,0,3)		ARDL(2,4,4,0)		ARDL(3,4,4,2,1,0)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Sweden, 2000Q1-2008Q3

Explanatory variable	Dependent Variable ΔSWE_SHADOW3		ΔSWE_RATE		ΔSWE_RATE	
ΔSWE_SHADOW3(-1)	0.9465***	(0.1470)				
ΔSWE_SHADOW3(-2)	-0.3030*	(0.1467)				
ΔSWE_SHADOW3(-3)						
ΔSWE_RATE(-1)			0.8267***	(0.1524)	1.0455***	(0.1278)
ΔSWE_RATE(-2)			-0.2203	(0.1587)	0.5950**	(0.2022)
ΔSWE_RATE(-3)						
ΔSWE_INF	0.3014***	(0.0864)	0.1988**	(0.0864)	0.0641	(0.0816)
ΔSWE_INF(-1)	-0.2861**	(0.1016)	-0.2475**	(0.1038)	-1.5173***	(0.2282)
ΔSWE_INF(-2)	-0.3959***	(0.0837)	-0.3779***	(0.0871)	-0.9757***	(0.1281)
ΔSWE_INF(-3)					-0.5313***	(0.1246)
ΔSWE_GAP	-16.1076**	(7.0086)	-12.9296*	(7.2034)	-25.2096***	(6.6861)
ΔSWE_GAP(-1)	-30.3220***	(7.1712)	-28.2596***	(7.1513)	-62.2932***	(9.6770)
ΔSWE_GAP(-2)					-27.6144**	(8.7085)
ΔSWE_GAP(-3)					-6.3492	(3.8765)
ΔSWE_PROPERTY	0.0036	(0.0101)	0.0019	(0.0104)	0.0317**	(0.0102)
ΔSWE_PROPERTY(-1)	0.0412***	(0.0120)	0.0349**	(0.0121)	0.0999***	(0.0150)
ΔSWE_PROPERTY(-2)	0.0439***	(0.0122)	0.0349**	(0.0125)	0.1199***	(0.0170)
ΔSWE_PROPERTY(-3)					0.0862***	(0.0162)
ΔSWE_STOCKS					-0.0273***	(0.0052)
ΔSWE_STOCKS(-1)					-0.0336***	(0.0069)
ΔSWE_STOCKS(-2)					-0.0315***	(0.0085)
ΔSWE_STOCKS(-3)					-0.0453***	(0.0089)
ECT(-1)	-0.8062***	(0.1158)	-0.7399***	(0.1159)	-1.9393***	(0.2349)
Constant	4.5216***	(0.6615)	3.9364***	(0.6263)	6.5144***	(0.8042)
Adjusted R-squared	0.7552		0.7186		0.8941	
Model	ARDL(3,3,2,3)		ARDL(3,3,2,3)		ARDL(3,4,4,4,4)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Sweden, 2008Q4-2021Q4

	Dependent Variable							
Explanatory variable	ΔSWE_SHADOW3		ΔSWE_SHADOW3		ΔSWE_RATE		ΔSWE_RATE	
ΔSWE_SHADOW3(-1)	0.5750***	(0.1207)	0.4791***	(0.0769)				
ΔSWE_SHADOW3(-2)	0.0019	(0.1269)	-0.0525	(0.0898)				
ΔSWE_SHADOW3(-3)	0.2979***	(0.0981)	0.2707***	(0.0777)				
ΔSWE_RATE(-1)					0.7112***	(0.099)	0.7258***	(0.0872)
ΔSWE_RATE(-2)					-0.0518	(0.1066)	-0.0046	(0.0951)
ΔSWE_RATE(-3)					0.2617***	(0.0784)	0.3070***	(0.0679)
ΔSWE_INF	0.1619**	(0.0669)			0.1049*	(0.0537)	0.0590	(0.0432)
ΔSWE_INF(-1)	-0.0768	(0.0774)			-0.1579**	(0.0608)	-0.1252**	(0.0488)
ΔSWE_INF(-2)	-0.1381**	(0.0645)			-0.0937*	(0.0474)	-0.0975**	(0.0411)
ΔSWE_INF(-3)								
ΔSWE_GAP					3.1644	(2.6694)		(0.0055)
ΔSWE_GAP(-1)					3.7651**	(1.8208)		(0.0063)
ΔSWE_GAP(-2)								
ΔSWE_GAP(-3)								
ΔSWE_PROPERTY	0.0040	(0.0091)			-0.0080	(0.0065)	-0.0161***	
ΔSWE_PROPERTY(-1)	0.0259**	(0.0109)			0.0288***	(0.0076)	0.0267***	
ΔSWE_PROPERTY(-2)								
ΔSWE_PROPERTY(-3)								
ΔSWE_STOCKS								
ΔSWE_STOCKS(-1)								
ΔSWE_STOCKS(-2)								
ΔSWE_STOCKS(-3)								
ECT(-1)	-0.3608***	(0.0562)	-0.4966***	(0.0442)	-0.3562***	(0.0512)	*-0.5005***	(0.0495)
GAP_DUMMY	0.3718	(0.2663)	0.5111***	(0.1850)	0.3141	(0.2697)	-0.1941	(0.1601)
Constant	1.7861***	(0.2916)	3.5045***	(0.3179)	1.4326***	(0.2153)	2.5354***	(0.2584)
Adjusted R-squared	0.7075		0.8012		0.8408		0.8752	
Model	ARDL(4,3,0,2)		ARDL(4,0,0,0,0)		ARDL(4,3,2,2)		ARDL(4,3,0,2,0)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Appendix 5 Short-run models

United Kingdom, 2000Q1-2008Q3

	Dependent Variable			
Explanatory variable	ΔUK_SHADOW3		ΔUK_RATE	
ΔUK_SHADOW3(-1)	0.4945**	(0.2026)		
ΔUK_SHADOW3(-2)	-0.2583	(0.2749)		
ΔUK_SHADOW3(-3)	0.4074	(0.3122)		
ΔUK_SHADOW3(-4)	-1.2263***	(0.3308)		
ΔUK_RATE(-1)			0.3884*	(0.1977)
ΔUK_RATE(-2)			-0.0443	(0.2507)
ΔUK_RATE(-3)			0.1527	(0.2796)
ΔUK_RATE(-4)			-1.2090***	(0.3145)
ΔUK_INF	0.8013**	(0.323)	0.7755**	(0.3046)
ΔUK_INF(-1)	0.2073	(0.229)	0.3762	(0.2142)
ΔUK_INF(-2)	0.7685**	(0.2959)	0.8412**	(0.279)
ΔUK_INF(-3)	0.2117	(0.2251)	0.2999	(0.2122)
ΔUK_INF(-4)	0.4419	(0.3373)	0.4407	(0.3148)
ΔUK_GAP	44.7925**	(18.2075)	44.4144**	(17.027)
ΔUK_GAP(-1)	-31.5669	(21.8571)	-27.9245	(20.0364)
ΔUK_GAP(-2)	40.9433*	(20.5916)	36.8381*	(18.4423)
ΔUK_GAP(-3)	-27.8725	(18.3316)	-18.7683	(17.1137)
ΔUK_GAP(-4)	23.1685	(17.2179)	17.0997	(16.3887)
ΔUK_CREDIT	0.0156	(0.0299)	0.0203	(0.0279)
ΔUK_CREDIT(-1)	-0.1020*	(0.0329)	-0.0941**	(0.0302)
ΔUK_CREDIT(-2)	-0.0514	(0.0388)	-0.0653	(0.0375)
ΔUK_CREDIT(-3)	-0.0829**	(0.0328)	-0.0843**	(0.0318)
ΔUK_CREDIT(-4)	-0.0393	(0.0321)	-0.0504	(0.0303)
Constant	0.2029*	(0.1092)	0.1975*	(0.1002)
Adjusted R-squared	0.5445		0.5878	
Model	ARDL(4,4,4,4)		ARDL(4,4,4,4)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Norway, 2000Q1-2008Q3

	Dependent Variable			
Explanatory variable	ΔNOR_RATE		ΔNOR_RATE	
ΔNOR_RATE(-1)	0.7786***	(0.153)	0.7636***	(0.1861)
ΔNOR_RATE(-2)				
ΔNOR_RATE(-3)				
ΔNOR_RATE(-4)				
ΔNOR_INF	-0.1243	(0.0915)	-0.1063	(0.0985)
ΔNOR_INF(-1)	0.2205**	(0.0879)	0.1410	(0.0887)
ΔNOR_INF(-2)	-0.2666***	(0.0877)	-0.1999*	(0.0966)
ΔNOR_INF(-3)				
ΔNOR_INF(-4)				
ΔNOR_GAP	15.6815*	(7.9308)	13.1936	(8.0671)
ΔNOR_GAP(-1)	10.1741	(9.5154)	18.5336*	(10.2523)
ΔNOR_GAP(-2)	-4.9273	(8.8883)	3.4083	(10.411)
ΔNOR_GAP(-3)	14.7737*	(7.1211)	18.7817**	(8.3737)
ΔNOR_GAP(-4)			10.9215	(7.4598)
ΔNOR_STOCKS	-0.0043	(0.0039)		
ΔNOR_STOCKS(-1)	0.0058	(0.0041)		
ΔNOR_STOCKS(-2)				
ΔNOR_STOCKS(-3)				
ΔNOR_STOCKS(-4)				
ΔNOR_CREDIT			-0.0414	(0.0305)
ΔNOR_CREDIT(-1)				
ΔNOR_CREDIT(-2)				
ΔNOR_CREDIT(-3)				
ΔNOR_CREDIT(-4)				
Constant	-0.0373	(0.0685)	0.0278	(0.0891)
Adjusted R-squared	0.5799		0.5865	
Model	ARDL(1,2,3,1)		ARDL(1,2,4,0)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Sweden, 2000Q1-2008Q3

Explanatory variable	Dependent Variable ΔSWE_SHADOW3		ΔSWE_RATE	
ΔSWE_SHADOW3(-1)	0.5047**	(0.2201)		
ΔSWE_SHADOW3(-2)	-0.6520**	(0.2661)		
ΔSWE_SHADOW3(-3)				
ΔSWE_SHADOW3(-4)				
ΔSWE_RATE(-1)			0.1661	(0.2042)
ΔSWE_RATE(-2)				
ΔSWE_RATE(-3)				
ΔSWE_RATE(-4)				
ΔSWE_INF	0.2563*	(0.1261)	-0.1426	(0.1333)
ΔSWE_INF(-1)	0.2174**	(0.0991)	0.1280	(0.1267)
ΔSWE_INF(-2)	-0.0074	(0.1192)	0.0826	(0.1276)
ΔSWE_INF(-3)	0.2894**	(0.1121)	0.2598**	(0.1060)
ΔSWE_INF(-4)	0.1759	(0.1233)	0.1831	(0.1269)
ΔSWE_GAP	-11.4026	(12.5511)	6.6694	(9.8337)
ΔSWE_GAP(-1)	9.9677	(8.9433)		
ΔSWE_GAP(-2)	24.3309**	(9.3684)		
ΔSWE_GAP(-3)				
ΔSWE_GAP(-4)				
ΔSWE_STOCKS	-0.0074	(0.0085)	-0.0119	(0.0088)
ΔSWE_STOCKS(-1)	0.0143	(0.0094)	0.0069	(0.0090)
ΔSWE_STOCKS(-2)			0.0001	(0.0107)
ΔSWE_STOCKS(-3)			0.0038	(0.0117)
ΔSWE_STOCKS(-4)			0.0265*	(0.0128)
Constant	-0.0701	(0.0450)	-0.0266	(0.0417)
Adjusted R-squared	0.5037		0.4829	
Model	ARDL(2,4,2,1)		ARDL(1,4,0,4)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis

Sweden, 2008Q4-2021Q4

	Dependent Variable			
Explanatory variable	ΔSWE_SHADOW3		ΔSWE_RATE	
ΔSWE_SHADOW3(-1)	0.3450**	(0.1321)		
ΔSWE_SHADOW3(-2)				
ΔSWE_SHADOW3(-3)				
ΔSWE_SHADOW3(-4)				
ΔSWE_RATE(-1)			0.4097**	(0.1555)
ΔSWE_RATE(-2)			-0.1741	(0.1626)
ΔSWE_RATE(-3)			0.0845	(0.1637)
ΔSWE_RATE(-4)			0.3625**	(0.1615)
ΔSWE_INF	0.0973	(0.1019)	0.2118**	(0.0889)
ΔSWE_INF(-1)	-0.0606	(0.1128)	-0.0419	(0.1009)
ΔSWE_INF(-2)	-0.2697***	(0.0985)	-0.1480	(0.0973)
ΔSWE_INF(-3)			-0.0839	(0.0980)
ΔSWE_INF(-4)			-0.1864*	(0.1025)
ΔSWE_GAP	11.7615**	(4.9662)	15.3564***	(4.6624)
ΔSWE_GAP(-1)	13.0087***	(4.0873)	14.1723***	(3.5370)
ΔSWE_GAP(-2)	11.4151***	(3.7914)	8.3962**	(3.1918)
ΔSWE_GAP(-3)	6.032**	(2.7423)	10.3275***	(3.1422)
ΔSWE_GAP(-4)	4.0634	(2.6489)	7.5904**	(3.3255)
ΔSWE_STOCKS	0.0048	(0.0056)	-0.0020	(0.0047)
ΔSWE_STOCKS(-1)	-0.0006	(0.0059)	-0.0028	(0.0051)
ΔSWE_STOCKS(-2)	-0.0114*	(0.0060)	-0.0077	(0.0050)
ΔSWE_STOCKS(-3)			-0.0093*	(0.0051)
ΔSWE_STOCKS(-4)			-0.0093	(0.0058)
GAP_DUMMY	1.5956***	(0.4847)	1.7503***	(0.4569)
Constant	-0.0601	(0.0464)	0.0234	(0.0425)
Adjusted R-squared	0.5654		0.6894	
Model	ARDL(1,2,4,2)		ARDL(4,4,4,4)	

* = 10 % level of significance, ** = 5 % level of significance, *** = 1 % level of significance

Standard error in parenthesis