Preface

This thesis is the end-result of my master's degree in economics at NTNU. It was written in cooperation with Norges Bank, and it would not have been possible without their valuable help. I wish to thank Ragnar Torvik, my supervisor at NTNU, for all the encouragement and good advices he has given me throughout the process. Several people at Norges Bank have contributed to this thesis, and their help has been greatly appreciated. Among them are Tord Krogh and Frank Hansen, whom I owe an especially great thanks to for their support and patience. I would not have dared to attempt VAR estimation without their assistance. This thesis is based on work done by Ørjan Robstad, and discussions with him have been most helpful. I also wish to thank André Kallåk Anundsen and Nina Larsson Midthjell at the bank for their good advices and feedback.

All views and statements in this thesis are my own, and cannot be assigned to Norges Bank. Any errors are entirely my own.

Abstract

There is an ongoing debate among economists and policy makers on whether the monetary policies followed by central banks in developed economies should be expanded to also include financial stability concerns. One way to include financial stability concerns in today's inflation targeting regime is through the policy known as leaning. Leaning means that in times of high financial instability, the central bank will temporarily increase the policy rate with more than what is justified by the traditional inflation and output stability concerns. The idea behind leaning is that this policy rate increase will affect some underlying financial variables, e.g. credit growth or house price growth, in a way that reduce the probability of a financial crisis in the future. This would be the benefit of leaning. However, leaning is not without costs; temporarily increasing the policy rate means increased unemployment in the following quarters. Whether central banks are justified in pursuing leaning depends on which is greater – the costs or the benefits?

In this thesis, I have calibrated Svensson's (2015) cost-benefit analysis of leaning for Norway, as well as examined some of the assumptions made in the original analysis. Svensson evaluates how a temporary 1-percentage point increase in the policy rate affects the benefit and cost of leaning in Sweden for the following 10 years. He uses a DSGE model in order to estimate the effect of the monetary policy shock, and he utilizes credit growth as the financial variable that enables the policy rate to affect the crisis probability. Svensson finds that leaning in Sweden has only costs, and no benefits, meaning that leaning is not justified. In my analysis for Norway, I find that although the benefit are generally outweighed by the cost, leaning do in fact have a long-term benefit. I further argue that this difference between the effects found of leaning in Sweden and Norway is not caused by differences between the two countries, but instead caused by Svensson's use of DSGE estimation, as opposed to my VAR estimation.

A common assumption made in cost-benefit analyses of leaning, and which is also made by Svensson, is that a crisis will incur a fixed increase in unemployment by 5 percentage points. However, the literature on financial crises has found that the crisis cost is increasing in the level of credit growth before the crisis erupted. This means that if leaning is successful in reducing credit growth, not only will it reduce the crisis probability, but it will also reduce the crisis cost. Although expanding the analysis to include this additional effect greatly increases the benefits of leaning, it is still found that the cost of leaning outweigh the benefit.

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1 Introduction

The fact that financial instability accumulated in the years leading up to the recent credit crisis with none of the warning bells going off, has re-sparked an old debate on monetary policy and financial stability. Both price stability and financial stability are important in order to achieve macroeconomic stability, but economists disagree on which weights the two objectives should be given in monetary policy decisions (see Haugland & Vikøren 2006). Several economists have called for further improvement to macroprudential frameworks that strengthens the structural resilience of the financial system, but others argue that this is not enough; we also need to utilize monetary policy if we are to avert future buildup of financial distress. There are mainly three camps in this debate on monetary policy and financial stability (see Evjen & Kloster 2012). In one end, there are those who believe that we need to completely rethink monetary policy; and in the other end are those who claim that traditional inflation targeting does not have to be reformed since the new macroprudential tools are near implementation and are much better suited to contain financial instability. In the middle are those who believe inflation targeting has almost gotten it right, but that it also needs to consider additional objectives than simply price and output stability.

There are two common arguments for why monetary policy should also target financial stability. The least radical argument is that distortions in financial markets can affect aggregate demand and inflation forecasts, and thus create deviations in the output and inflation gaps. Some go further in claiming that monetary policy can be an independent source for buildup of financial instability by encouraging excessive risk-taking and leveraging. Those who oppose a new take on monetary policy, claim that the reason why monetary policy was supposed to achieve inflation and output stability in the first place (and largely ignore movements in asset prices and credit aggregates), was the belief that it is too difficult to distinguish fundamental-driven movements from speculative bubbles ex ante (Bernanke & Gertler 2001, Mishkin 2008, Gali & Gambetti 2015). Besides, the policy rate is a too coarse instrument anyway to address the associated financial risks. They argue that if monetary policy has a role, then it is to respond to the consequences of financial crisis after it has materialized. This debate is often summed up as "leaning against the wind vs. cleaning up after the crash" (IMF 2015).

There is a large consensus that the new macroprudential tools in combination with traditional microprudential policies should supply the first line of defense against financial instability.

The disagreement however, is about whether the central bank should supply a second line of defense through leaning. Leaning means that whenever there is a buildup of financial instability, the central bank tightens monetary policy more than it would have done otherwise if it was simply concerned with inflation targeting. It is the uncertainty regarding how effective the new macroprudential toolkit is in regulating and monitoring financial institutions that has spurred some central banks to implement leaning. After all, it is the central bank that is left with the clean up after the crash. Some central banks, such as Norges Bank, have explicitly stated that they are regarding financial stability concerns in their adjustments of the policy rate through the policy referred to as "leaning against the wind" (Olsen 2015).

However, leaning is not without costs; tightening monetary policy will incur a higher unemployment rate in the following periods. The benefit of leaning are, on the other hand, collected in the medium term in the form of reduced probability of the economy experiencing costly financial crises. Whether central banks are justified in utilizing the policy rate in order to avoid buildup of financial instability risk hinges on the question whether the benefits from leaning outweigh the costs. There have been some attempts at cost-benefit analyses of leaning, the most influential one is perhaps the one by Svensson (2015). As most other cost-benefit analyses on leaning, Svensson has used credit growth as the transmitter between the policy rate and financial stability. The literature on the causes of financial crises have shown how rapid credit growth is a common factor for previous incidents of financial turmoil, and a good indicator for the probability of the economy experiencing a crisis in the near future (see i.e. Schularick & Taylor 2012). Svensson finds overwhelming evidence *against* leaning. In his analysis on Swedish household data, he finds that leaning has no benefits, only costs.

The objective of this master thesis is to closer examine the robustness of the conclusions drawn by Svensson. First, I wish to investigate whether Svensson's results, which are based on Swedish data, still applies when based on Norwegian data. Leaning might incur larger costs than benefits in Sweden, but it is not given that the result will be found in other countries. I therefore follow the advice given by the IMF (2015), which claims that all evaluations on leaning should be state contingent. In order to estimate the effect of a monetary policy shock in Norway, I use VAR estimation based on a model by Robstad (2014), as opposed to the DSGE estimation used by Svensson. Contrary to Svensson, I do find that leaning has a benefit, although it is generally not large enough to counteract the cost. However, by substituting both the estimation method and the sample country in my benchmark model, I have confounded the effect of different estimation methods and the effect

of different sampling countries on the result. In order to clarify what is causing the difference between my results and Svensson's, I also re-do Svensson's analysis on Swedish data, but using VAR estimation. This exercise implies that it is in fact Svensson's use of DSGE estimation that is causing the absence of benefits from leaning, and not differences between Norway and Sweden.

Furthermore, I wish to clarify a dilemma inherent in Svensson's framework for analyzing leaning by closer investigating the effect of high and low credit growth on the benefit and cost. While a higher credit growth will generally increase the benefit of leaning, it will also increase the cost of leaning. Hence, leaning is always more costly when credit growth is high, and thus the crisis probability is high, which is arguably when leaning is most needed. I also wish to adjust for a crucial assumption made by Svensson regarding the cost of crises. It is assumed that financial crises will incur a fixed increase in unemployment by 5 percentage points. Although Svensson has some basis for this assumption (see Claessens et al. 2010), new work by Jorda, Schularick & Taylor (2013) seems to indicate that leaning can have a decreasing effect on the crisis cost. They have found that financial crises are in general more costly when the crises are preceded by excess credit growth. If leaning is able to reduce the credit growth, it will not only reduce the crisis probability, but it will also reduce the crisis cost. I expand Svensson's analysis to include this additional effect of leaning, and while I do find a large increase in the benefit of leaning, the cost is still greater.

In chapter 2 I give a summary of the literature on financial crises, the different arguments for and against leaning, as well as elaboration of the mechanism behind leaning. Chapter 3 gives a summary of Svensson's analysis, while the findings from my benchmark model is summarized in chapter 4. Chapter 5 gives a clarification of the effect of high and low credit growth within Svensson's framework for analysis, while the assumption of a fixed crisis costs is adjusted in chapter 6. Chapter 7 summarizes the findings when the model is executed on Swedish data and VAR estimation. Chapter 8 summarizes and concludes, as well as offers some further considerations for future analyses of leaning. Readers interested in the construction of the dataset and the VAR model in the case of Norway and Sweden are referred to appendix 1 and 2, respectively.

2 Theoretical background

It seems that every time the economy is struck by financial turmoil, there will be those who claim that this crisis differs from previous incidents: It might be the causes, the magnitude or the manifestations of the crisis; nevertheless, it is claimed that this time around was different. Academics have, on the other hand, shown that this sentiment is problematic. Every crisis is of course in some ways unique, but financial crisis post-WWII in developed economies have shared some striking similarities, such as sharp run ups in asset prices, debt accumulation, growth patterns, and current account deficits (Reinhart & Rogoff 2008). The financial crisis of 2008 was no exception (Reinhart & Rogoff 2014). These developments in the pre-crisis period are often accompanied by a financial liberalization and de-regulation of the banking sector (Kaminsky & Reinhart 1999). The literature on early warning systems has in fact found deviations in asset prices and debt accumulation from their trends to be especially good indicators on financial crisis, not only in sample, but also out of sample (see Riiser 2005, Borio & Drechmann 2009, Acharya & Richardson 2009, Barrell et al. 2010, and Anundsen et al. 2014).

The call for a new approach to monetary policy is partly caused by the realization that price stability is not sufficient to ensure financial stability as well, considering how past experiences have shown that financial crises are not necessarily preceded by inflationary pressure (White 2006). This was certainly the case with the recent financial crisis: despite large run ups in credit-to-GDP gaps and real estate prices, inflation and output gaps were at the time seemingly close to their targets (IMF 2015). Some economists have gone as far as to claim that an overly expansionary monetary policy can play a decisive role in trigging crises by increasing risk-taking and leveraging in the economy (Taylor 2007, Borio & Zhu 2008, Diamond & Rajan 2009). Leijonhufvud (2008) claim that it was the strict inflation doctrine followed by the Federal Reserve that led to the recent crisis. The story goes that as an effort to counteract the effects of the dot.com crash, the Fed lowered the policy rate drastically, and managed to somewhat contain the negative impact of the dot.com crash. However, they continued to maintain an extremely low policy rate because inflation stayed at a low and constant level for the following years. In an inflation targeting regime, this is taken as a signal that the interest rate is kept at the correct level. Leijonhufvud, on the other hand, argues that the level of consumer goods prices was not kept down because the inflation targeting regime was working, but in reality kept down because of increased competition from abroad through imports and the exchange rate policies in those exporting countries. American monetary

policy was in fact too lax, and it led to the buildup of a serious asset price bubble, especially in real estate, and consequently a deterioration in the quality of credit with the so-called sub-prime mortgages.

Other proponents of leaning are less dismissive of traditional inflation targeting. Some claim that rather than discrediting traditional inflation targeting, the events of the last several years have shown how inflation targeting helps alleviate the consequences of financial turmoil (Woodford 2012). Despite the magnitude of the credit crisis in 2007, and the large swings in oil prices the last couple of years; all of the major economies have escaped the deflationary spiral and the effects of dynamics of wage and prices have been modest. An explanation of these less severe effects is that inflation expectations in most of the major economies have remained for the most part unaffected. Schularick & Taylor (2012) have shown how the collapse in broad money and deflation that usually accompanied crises in the pre-WWII era, have mostly been avoided after WWII, though financial crises still have real costs. The financial turmoil does, however, discredit one aspect of inflation targeting: The idea that as long as the central bank follows inflation targeting, it does not need to monitor financial developments as long as those developments do not affect the outlook for inflation (Woodford 2012, IMF 2015).

DeGrauwe (2007) claims that the justification of a strict inflation targeting doctrine is dependent on the assumption that banking is separated from the financial markets. In that case, asset price bubbles and its subsequent crash will affect only the non-banking sector; and it is not the central bank's task to insure private portfolios. However, the recent crisis have proved how the banking sector is not at all insulated from movements in the asset markets. Quite contrary, the banks were heavily involved in the creation of the housing price bubble. As a consequence of being the lender of last resort, the central banks also became heavily involved in the crisis that followed. This interdependency between banking and financial markets can be understood by the historical developments of credit and broad money. Schularick & Taylor (2012) have shown how after WWII credit has experienced a substantial growth, not only compared to GDP, but also relative to broad money. This has been made possible through a combination of higher leverage and the use of new non-monetary sources of funding. The result is that whatever happens in financial markets now matters more for credit creation, and consequently also for financial stability. This development correlates with the frequency of financial crisis. The frequency of financial crisis in the 1945-71 period was

almost zero, while from 1971 and onwards financial crisis occurred with a 4% annual probability.

There are several reasons to why proponents of the strict inflation targeting doctrine are against the idea of adding an additional goal of financial stability to the usual inflation and output gap stabilizing goals (see Woodford 2012, and Evjen & Kloster 2012 for a summary). They argue that even though it is highly desirable to avoid financial crisis, such crises are not predicable enough that policies such as leaning can be justified. This sentiment is particularly strong in the proposal of the central bank using monetary policy to "prick" asset price bubbles – why should the central bank know the correct valuation of assets when none of the market participants have gotten it right? They further argue that even if we did know how to predict crisis, we still do not know how much monetary policy can actually do to prevent the buildup of financial instability. Their position is that it is better for the central bank to "mop up" after a crisis instead of trying to "lean against" it, since at least then the effect of monetary policy is much clearer and well established. Others have gone further by suggesting that even if there are grounds for using monetary policy as a tool to prevent the buildup of financial instability, surely there must be other more effective tools to use than monetary policy. This is in accordance with the principle that one should use at least as many instruments as there are goals, and that it would be overreaching to try and hit three birds with one stone. Consequently, the policy rate should be used to achieve inflation and output stabilization, while financial stability should be a task of supervisory and regulatory policy.

Central banks have little reason to believe that they are able to "prick" asset price bubbles. Gali & Gambetti (2015) have in fact shown how a policy rate increase in order to reduce the bubble formation in stock markets, can lead to an increase in the bubble component of stock prices, and thus *increase* financial instability. Woodford (2012) argues, however, that the issue is not whether the central bank is able to identify overvaluation of one asset or another; instead, "the issue is whether the central bank is able to recognizing situations where the probability of simultaneous financial distress at several institutions is non-trivial". This means that the central bank does not have to be able to predict financial crises, instead they must be able to identify under which conditions does financial risk increase. The literature on early warning system has much to contribute on this topic. Monetary policy might not be able to prick asset price bubbles, but it is able to deter extreme levels of leverage and the seek for excessively short-term sources of funding in the financial sector.

Woodford further argues that the claim that it is better to simply mop up after the crisis than try to prevent it, seems rather odd considering the enormous costs that financial crises inflict on the economy. Even though many of the severe consequences of crises have been avoided in the post-WII era; not only has the crisis probability increased, but also the costs of financial crises have in fact increased, despite crises now being fought with more aggressive monetary policies (Schularick & Taylor 2012). Financial crises have also been shown to generally be more costly than regular economic recessions, and perhaps more importantly, the costs are increasing in the degree of household leverage (Mian & Sufi 2010; Jorda, Schularick & Taylor 2013). The recent financial crisis have demonstrated that despite almost heroic efforts from central banks, they were not able to avoid a sharp fall in worldwide trade and activity. Even years after the onset of the crisis, some economies are still struggling with high levels of unemployment and debt (Evjen & Kloster 2012). The ability of monetary policy to contain financial risk might still be somewhat uncertain and in need of more research. Nevertheless, considering the cost of financial crises, and if monetary policy in fact is a contributor (or at least a conductor) for financial turmoil; then the idea that central banks should completely dismiss financial stability concerns in their policy rate decisions can seem like a rather extreme position to hold.

Kaminsky & Reinhart (1999) have pointed out how financial crises are usually preceded by financial liberalization. In the aftermath of the recent crisis, new tools have been developed to contain financial instability buildup. Opponents of leaning have suggested the financial stability concerns should be left to the traditional supervisory and regulatory policies and to the new tools that are referred to as a macroprudential framework; while monetary policy should continue to only be concerned with price and output stability. Woodford (2012) argues that this stance is only justified if these instruments and tools are able to completely eliminate financial instability concerns, and without costs of using these instruments. Few economists seem to believe that the new macroprudential tools will be able to fully contain financial instability risks (Evjen & Kloster 2012). While an adjustment of monetary policy to include financial stability concerns no doubt has costs, it is highly unlikely that these new macroprudential are without welfare losses as well (Evjen & Kloster 2012). Proponents of leaning do not suggest that monetary policy should be used to contain all financial risk. Instead, traditional micro-prudential frameworks in combination with the new macroprudential tools should shoulder most of the burden of containing financial instability, while monetary policy supplies a second line of defense (IMF 2015).

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2.1 The mechanism behind leaning

The mechanism behind leaning is that in periods when the central bank suspects growing financial instability, they increase the policy rate more than what inflation stability demands. The increased policy rate is supposed to affect some kind of financial variables, which will ultimately lead to higher financial stability. The mechanism of leaning can be illustrated as following:

Policy rate	Link 1 →	Financial variable	Link 2 →	Financial stability
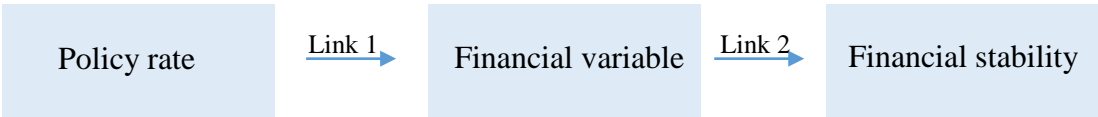
In order to evaluate the effectiveness (in terms of cost and benefit) of leaning, there are two links that must be accounted for. The first link is the effect the policy rate has on different financial variables, while the second link is the effect these variables have on financial stability in the economy. I start with the latter link in the more detailed explanation below, before I move on to the first.

Link 2: Financial variable ⟶ Financial stability

Obviously, there are several different financial variables that affect the financial stability of the economy. The variables that have received attention among economists are mainly the leverage of financial firms, household debt, bank risk taking, asset price growth (especially real estate) and credit spreads (IMF 2015). Reinhart & Rogoff (2008) identify several leading indicators for episodes of financial instability. Among them are rapid increases in housing prices, equity prices and credit to GDP; combined with increased current account deficits measured as a share of GDP. This lends evidence to the claim put forward by Borio & Drechmann (2009) that we can predict financial crises in real time by measuring the coexistence of asset price misalignment and a limited capacity of the economy to withstand a potential asset price reversal.

A common objection against using monetary policy to prevent the buildup of financial distress is the sentiment that financial crisis are best predicted in hindsight. However, the literature on early warning systems have shown how it is possible to develop models that can detect growing financial instability before a crisis erupts. This enables central banks to separate sustainable developments in credit and asset prices from those which are not, thus

making central banks capable of predicting financial crisis in real time and not only in hindsight. Borio & Drechmann (2009) have for instance developed a signaling system for financial distress by estimating different variables' ability to correctly sort a sample into crisis and non-crisis periods while minimizing the probability of rejecting a true signal and failure to reject a false signal (type 1 and type 2 errors, respectively). They found that their indicator based on deviation from long-term trend in credit growth, equity and property prices would have managed to detect the buildup of financial distress before the crisis erupted in 2008. Barrell et al. (2010) find that property prices have an especially predictive power for financial distress. In their early warning system, they find that an increase in real house price growth by 1 percentage point leads to an increase in the probability of a crisis between 0.07 % and 0.74 %, depending in the country. A rather large increase given that the average crisis probability in the sample was 3.2 %.

The relationship between the financial stability and financial variables that is perhaps most empirically established is the relationship between aggregated credit growth and financial stability. The common estimation method has been a standard logit regression, which investigates the predictive power of credit growth on whether there is going to be a financial crisis next period. The seminal work of Schularick & Taylor (2012) has empirically established a link between a country's recent history of credit growth and the probability of a financial crisis. Based on observations for 14 advanced economies during the period 1870-2008, they find that the accumulated annual growth rates of bank loans during the last five years are jointly significant predicators for the probability that a financial crisis will occur next year – lending evidence to the conception that financial crises are in fact "credit booms gone wrong". They estimate that an increase of one standard deviation in real loan growth increases the probability of a crisis by about 2.8 percentage point, which is a substantial increase given that the average annual probability of a crisis in their sample is 4 %. Their results are supported by a similar study by Laeven and Valencia (2012), which utilizes a shorter time series.

Studies done on early warning systems indicate that it is quite possible for central banks to develop indicators for when there is a buildup of financial distress. Especially growth in credit and asset prices stand out as leading indicators for financial distress. That leads us to the next question: Given that the central bank can predict financial crises, can they use monetary policy to avert the impending crisis?

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Link 1: Policy rate ———▶ *Financial variable*

From the section above, we know that there is a relationship between financial stability and credit and assets prices; but in order for leaning to be a feasible policy for achieving financial stability, there must also be a clear and significant relationship between the policy rate and these financial variables.

It would greatly improve the case for leaning if the policy rate has the ability to influence the real levels of credit. Unfortunately, economic theory suggests that monetary policy is neutral in the long run and cannot therefore have long term effects on real variables such as credit growth. Nevertheless, the actual effect of the policy rate on credit remains an empirical question. There have been several studies aiming at empirically investigating the relationship between the policy rate and real credit levels. Even though there are large differences in the estimates across countries, the empirical evidence largely points in the direction of a rather modest effect on credit by increases in the policy rate. Assenmacher-Wesche and Gerlach (2008) find no significant effect of increased policy rate on credit in Norway¸ while Robstad (2014) finds only a small effect; a temporary increase in the policy rate of 1 percentage point leads to a decrease in Norwegian household real debt by 0.7 % after 4 quarters. Estimates from the Sveriges Riksbank (2014) are largely in line with the Norwegian estimates; they show that the same increase in the policy rate leads to a decrease in Swedish household real debt by 1 % after 8 quarters.

The results from other developed economies are not more encouraging: Recent studies from other countries on the effect of a monetary tightening on real credit levels find that a temporary 1-percentage point increase in the policy rate leads to a decrease in real credit between 0.3-2 % after 4-16 quarters (IMF 2015). These are rather small effects given such a large increase in the policy rate. The case for leaning where aggregate credit variables are used as indicators for financial distress does not seem very promising, given the weak effect of the policy rate on credit. Svensson (2013) goes as far as suggesting that leaning might even cause more financial distress through its effect on credit. He claims that household debt-to-GDP might increase following a policy rate increase, and thereby increase financial distress. This will be the case if the level of credit moves sluggish in response to the policy rate increase, relative to the changes in GDP. Sveriges Riksbank (2014), however, disagrees with Svensson, as they do not find this effect in in their estimation.

In addition to measures of credit, asset prices have been suggested as an indicator for financial stability given the sharp increases in asset prices that have preceded financial crises in the past, and the perception that fluctuations in asset prices are in large driven by bubbles. The results found by Gali & Gambetti (2015) imply that it would be rather counter-productive to target stock prices, as leaning might increase the bubble component of stock prices, and thereby increase financial instability. Besides, movements in stock prices are much too volatile to be a suitable target for financial stability.

Since the literature on early warning systems have shown that property prices have predicative power (see Borio & Drechmann 2009, Barrell et al. 2010), another strategy would be for central banks to utilize property prices as the link between the policy rate and financial distress. This view is strengthened by studies done on Norwegian data, which have found that movements in the policy rate have a significant and substantial effect on property prices (Bjørnland & Jacobsen 2010, Robstad 2014). Studies on other developed economies have also found a similar relationship. In a cross-country analysis by Sutton (2002) it is estimated that an increase in the short term policy rate leads to a decrease in housing prices in the range of 0.5-1.5 percentage points over 4 quarters. However, the effect of the policy rate on property prices varies substantially across countries, and it is seemingly larger in Norway than in other developed economies (Robstad 2014). Nevertheless, using property prices as the link between the policy rate and financial stability seems promising, at least in Norway.

In conclusion, it appears possible to use credit and asset prices as indicators for financial distress. This is not surprising considering the large increases in credit and asset prices that have usually preceded financial crises. The challenge, however, is the link between the policy rate and these financial variables. The empirical evidence is not encouraging in the case of credit and stock prices. Property prices, on the other hand, are both affected by the policy rate and have been shown to be a good indicator for financial distress.

2.2 Cost and benefit of leaning

Increasing the policy rate above what is justified by minimizing the inflation and output gaps, will incur costs in the short run by decreasing inflation and output, and thus increasing unemployment. The benefits of leaning, however, are not gained until the medium run in the form of reduced probability of entering a crisis, and thus avoiding the large costs associated with crises. Some studies have tried different ways to estimate these costs and benefits. They

all have in common that they have utilized credit growth as the financial variable that links the policy rate to financial stability.

In their cost-benefit analysis of leaning, the IMF (2015) employs the estimates found by Schularick & Taylor (2012) on the link between credit growth and crisis probability. Further, based on earlier studies done by others, they find that the reduction in the probability of crisis accumulates from 0 to 0.2 percentage points over the four years following a 1 percentage point increase in the policy rate. Their framework is a two-period model where the probability of a crisis being triggered in the second period is lower if the central bank leaned in the first period. They estimate the welfare loss in the first period by using their own DSGE model, which implies that a temporary 1-percentage point increase in the policy rate will increase unemployment by 0.5 percentage point for 3-4 years. They assume that the severity of a crisis varies between 5-7 percentage points increase in unemployment, and the length varies between 4.5-8 years. By utilizing a loss function that measures the squared deviations in the unemployment rate, the IMF concludes that the cost of leaning generally appear greater than the benefits. However, because of the large uncertainties in their estimates the IMF also concludes that it is imperative that any evaluation of leaning should be state contingent, and avoid being based on broad averages.

Ajello et al. (2015) study the cost and benefits of leaning in a similar two-period. The welfare loss in period 1 caused by the increased policy rate is reduced inflation and production, and assuming that inflation and production were at target to begin with, we now have positive inflation and output gaps. The welfare loss in a crisis (period 2) is dependent on the further increases in inflation and output gaps (the assumption is 10 % and 2 % decline in output and inflation, respectively) and the length of the crisis (assumed 8 quarters). The loss in period 1 increases with the policy rate, while the loss in period 2 decreases with the policy rate since increased policy rate means a lower credit growth and thus lower probability of entering period 2. The optimal increase in the policy rate therefore balances the loss created by increased inflation and output gaps today, with the gain of decreased probability of entering a crisis in the future. Ajello et al. find that given a long-term rate of 4 %, the optimal increase in the policy rate is only 0.03 percentage points in their preferred model. The reason for this low

degree of leaning is the small effect the policy rate has on credit growth, and thus the probability of entering a crisis[1].

Svensson (2015) claims that the two-period framework used in studies such as the one done by Ajello et al. (2015) is an over-simplification. He claims that the results will be skewed since this framework disregards the possibility of a crisis in the first period, and it assumes that if a crisis occurs in the second period then the economy will start at the long-run sustainable unemployment rate (i.e. fixed increase in the output and inflation gap). The result is an *understating of the cost* by not taking into consideration that leaning causes the economy to start from a higher unemployment rate when a crisis occurs. The two-period framework also leads to an *overstating of the benefits* by assuming that there is only one period where the probability of a crisis can be affected, thus disregarding the consequences of potential long-run neutrality of monetary policy which will cause the probability of crisis to be shifted between periods. Svensson, on the other hand, analyzes how the cost and benefit on leaning develops over the following 40 quarters following a temporary 1-percentage point increase in the policy rate.

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[1] Recalibration of the model can lead to a higher optimal degree of leaning. For instance, if the severity of the crisis is comparable to that of the Great Depression, or if the crisis probability is twice more responsive to changes in credit growth, the optimal increase in the policy rate is as large as 0.5 percentage points.

3 Summary of Svensson's analysis of leaning

What makes Svensson's analysis of leaning stand out from other cost-benefit analyses is the fact that Svensson examines the continuous development of the cost and benefit of leaning over a 10-year span, as opposed to a simple two period model. He first examines how a temporary increase in the policy rate today affects the expected future unemployment rate over the next 40 quarters. He further executes a more formal cost-benefit analysis by examining how the same temporary increase in the policy rate affects the economy's welfare, measured by a quadratic loss function. He also demonstrates the robustness of his results to an array of different scenarios, including a less efficient macroprudential policy. All figures in this chapter are from the analysis in Svensson (2015).

3.1 The expected future unemployment rate

In the event of a crisis, the crisis unemployment rate (u_t^c) will be given by the non-crisis unemployment rate (u_t^n), plus a constant mark-up induced by the crisis (Δu),

$$u_t^c = u_t^n + \Delta u > u_t^n$$

The probability of a crisis occurring in quarter t is given by q_t, and in the event of a crisis it is assumed that it will last n quarters. This implies that the probability of the economy being in a crisis state in quarter t, p_t, is given by the sum of the probabilities of a crisis occurring in the n-1 previous quarters,

$$p_t = \sum_{\tau=1}^{n-1} q_{t-\tau}$$

The expected future unemployment rate in quarter t at time 1 can therefore be written as the weighted sum of the expected unemployment rate in the two different states,

$$E_1 u_t = (1 - p_t)E_1 u_t^n + p_t E_1 u_t^c = (1 - p_t)E_1 u_t^n + p_t(E_1 u_t^n + \Delta u) = E_1 u_t^n + p_t \Delta u$$

Svensson analyses how a given increase in the policy rate affects the expected future unemployment rate. He assumes that the policy rate is increased by 1 percentage point the next four quarters, and then gradually reduced to its initial level: $i_t = \overline{\iota_1}$, for $1 \leq t \leq 4$

The effect of the increased policy rate on the expected future unemployment rate is given by the derivative of the expression above,

$$\frac{dE_1 u_t}{d\bar{\iota}_1} = \frac{dE_1 u_t^n}{d\bar{\iota}_1} + \Delta u \frac{dp_t}{d\bar{\iota}_1} \qquad (1.1)$$

The first term expresses the effect on the expected unemployment rate in non-crisis times by an policy rate increase, while the second term gives the effect the policy rate has on the expected unemployment rate if a crisis was to occur. Svensson utilizes several sources to empirically estimate these relations:

The first term: This is the standard effect of a policy rate increase on the unemployment rate. Svensson draws on the Sveriges Riksbank's standard model (DSGE modell Ramses) in order to estimate this effect. The effect of a 1-percentage point increase in the policy rate on the unemployment rate is illustrated in figure 3.1 for the following 40 quarters after the increase. From the figure, we can see that the increase in the policy rate leads to a gradual increase in the unemployment rate. The maximum increase in the unemployment rate is reached in quarter 6 with 0.5 percentage point above baseline. The unemployment rate then gradually falls back toward its baseline, which is reached around quarter 40.
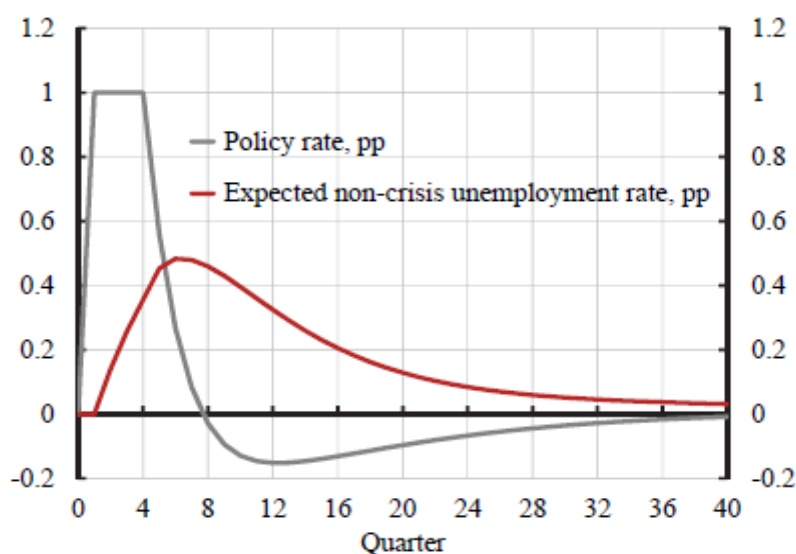
Figure 3.1: The effect of the monetary policy shock on the policy rate and the non-crisis unemployment rate, in Svensson's analysis.

The second term: Svensson assumes that $\Delta u = 5$, which implies that the occurrence of a crisis will increase the unemployment rate by a fixed amount of 5 percentage points. In order to find the effect of the policy rate on the probability of the economy being hit by a financial crisis, one must establish the relation between the policy rate and credit growth, and the relation between credit growth and crisis probability.

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The effect of credit growth on crisis probability: Svensson utilizes the work done by Schularick & Taylor (2012) in order to estimate the effect of credit growth on the probability of a crisis starting at quarter t. Schularick & Taylor find that a 5% lower credit growth during the next 5 years reduces the annual probability of a crisis start with 0.3 percentage points. This further implies a quarter wise probability reduction of 0.075 percentage points.

The effect of the policy rate on credit growth: Svensson estimates this relation by using work done by the Sveriges Riksbank (2014) which estimates the effect of the policy rate on Swedish household real credit level, d_t. This relation is illustrated in figure 3.2.
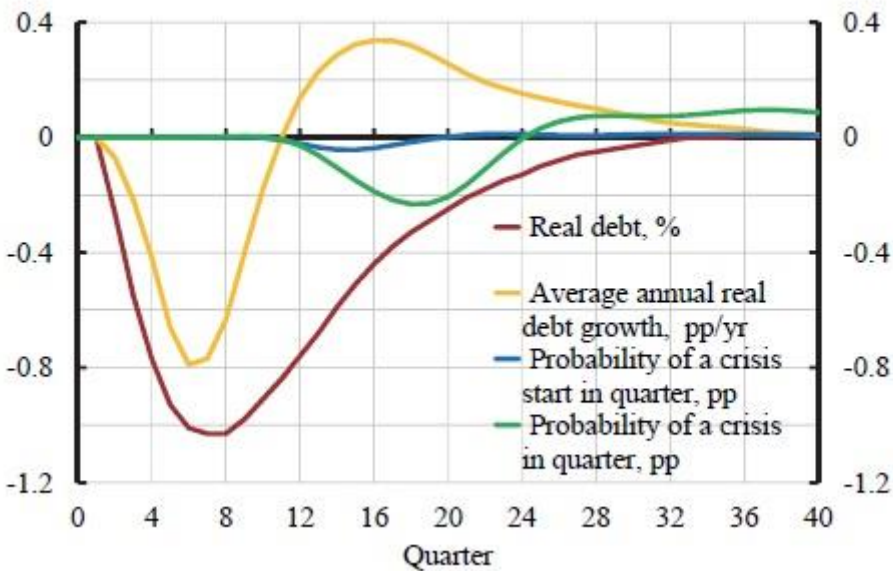
Figure 3.2: The effect of the monetary policy shock on credit and the crisis probabilities in Svensson's analysis.

Sveriges Riksbank estimates that the increase in the policy rate leads to a 1 % reduction in the real level of household credit over the next two years. The decrease is not permanent; the real credit level will eventually increase and reach its baseline level after 8 years. Neutral monetary policy implies an absence of permanent effect on real credit levels after a temporary policy rate increase.

The red line in the figure above can be interpreted as $\frac{d(d_t)}{d\bar{\iota}_1}$ for $t \geq 1$, and where $\frac{d(d_t)}{d\bar{\iota}_1} \approx 0$ for $t \geq 32$. In other words, the initial effect the policy rate increase had on real credit level disappears after 32 quarters, when credit returns to its initial level.

The yellow line shows the credit growth, g_t. As the credit level falls below its baseline, the credit growth will also fall below baseline, but since the credit level eventually converges back to its initial level, the credit growth must increase and is pushed above baseline. Because monetary policy is neutral with regards to the real credit level, monetary policy will also be neutral with regards to the credit growth. Hence, the temporary policy rate increase will have no long-term effect on the credit growth.

The yellow line can be interpreted as the derivative of the quarterly credit growth, and since monetary policy is neutral, we will have to following result,

$$\sum_{t=1}^{40} \frac{dg_t}{d\bar{\iota}_1} \approx 0$$

Further, the crisis probability will display the same pattern as the credit growth: Following the policy rate increase, the probability of a crisis will first fall, but then increase above its initial level in accordance with the credit growth but with a 2-year lag (see Schularick and Taylor). Thus, after 5 years the crisis probability will have grown above its initial level before the policy rate increase. In conclusion, leaning will initially cause the probability for a crisis start to fall below its baseline, but eventually the crisis probability will grow above its baseline when the credit level converges back to its baseline. Thus, the only effect of leaning is to transfer the probability of a crisis start between periods. Since the cumulative effect of the policy rate increase on credit growth is approximately zero, also the cumulative effect on the probability of a crisis start will be approximately zero,

$$\sum_{t=1}^{40} \frac{dq_t}{d\bar{\iota}_1} \approx 0$$

Further, since the probability of the economy being in a crisis state at time t is the sum of the probabilities for a crisis start in the (n-1) previous periods, the policy rate increase will not have an effect on the probability of the economy being in a crisis at time t either,

$$\sum_{t=1}^{40} \frac{dp_t}{d\bar{\iota}_1} \approx 0$$

From figure 3.2, we can see that the increase in the policy rate will, according to Svensson's estimates, lead to reduced crisis probability after 3 years, and then to an increased crisis probability after 6 years. The cumulative effect will on the other hand be approximately zero.

Given the estimates of $\frac{dE_1 u_t^n}{d\bar{\iota}_1}$, $\frac{dp_t}{d\bar{\iota}_1}$, and Δu discussed above, the total effect of the temporary policy rate increase on the expected future unemployment can be illustrated as following:
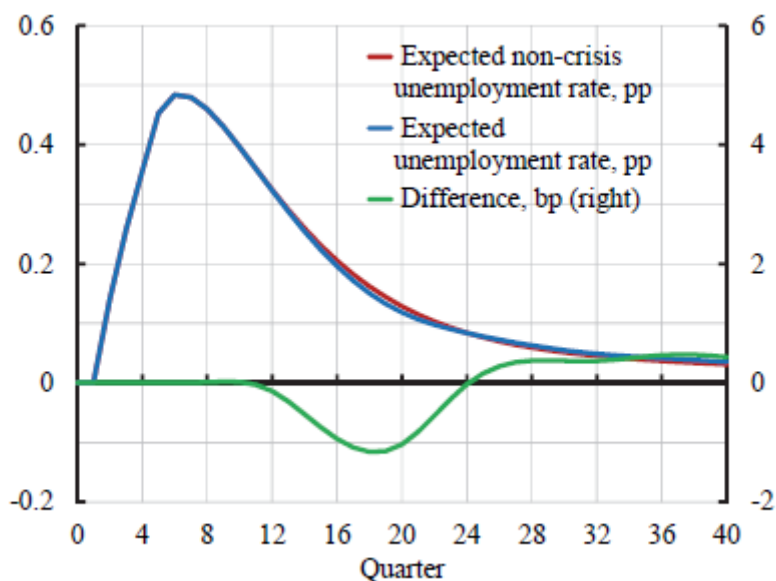
Figure 3.3: The effect of the monetary policy shock on the expected non-crisis unemployment rate and the unemployment rate, in Svensson's analysis.

In figure 3.3, Svensson illustrates how the curve for the expected unemployment rate at time t coincides almost exactly with the curve for the expected unemployment rate when the economy is not in a crisis state,

$$\sum_{t=1}^{40} \frac{dE_1 u_t}{d\bar{\iota}_1} = \sum_{t=1}^{40} \frac{dE_1 u_t^n}{d\bar{\iota}_1} + \Delta u \sum_{t=1}^{40} \frac{dp_t}{d\bar{\iota}_1} \approx \sum_{t=1}^{40} \frac{dE_1 u_t^n}{d\bar{\iota}_1}$$

The reason for this result is the fact that in Svensson's framework the policy rate has only a modest effect on the crisis probability, in addition to the fact that after a couple of years the policy rate increase will have an positive effect on the crisis probability. In the long-run, the cumulative effect on the crisis probability will be close to zero.

3.2 Leaning evaluated by a quadratic loss function

Svensson points out that it is not sufficient to evaluate leaning only by studying the development in the expected future unemployment rate given that the marginal welfare loss of increased unemployment is increasing the further away unemployment is from its target. Consequently, Svensson also evaluates leaning by studying the effect it has on the welfare loss measured by a quadratic loss function.

Svensson defines: $\widetilde{u_t^n} = u_t^n - u_t^*$ og $\widetilde{u_t^c} = u_t^c - u_t^*$

Where $\widetilde{u_t^n}$ and $\widetilde{u_t^c}$ are the unemployment gaps under the policy of leaning in non-crisis times and crisis times respectively, and where u_t^* is the unemployment rate under an optimal inflation targeting regime where the crisis probability is disregarded (benchmark).

Svensson defines the following expression for the expected intertemporal welfare loss,

$$E_1 \sum_{t=1}^{\infty} \delta^{t-1} L_t \;=\; \sum_{t=1}^{\infty} \delta^{t-1} E_1 L_t$$

Where δ is the discounting factor, and L_t is the loss function given by,

$$L_t = (\widetilde{u_t})^2$$

Svensson further defines the expected loss in quarter t as the weighted sum of the squared expected unemployment gap in non-crisis times and crisis times,

$$E_1 L_t = E_1(\widetilde{u_t})^2 = (1 - P_t) E_1 \left(\widetilde{u_t^n}\right)^2 + p_t E_1 \left(\widetilde{u_t^c}\right)^2$$

$$= (1 - P_t) E_1 \left(\widetilde{u_t^n}\right)^2 + p_t E_1 \left(\widetilde{u_t^n} + \Delta u\right)^2 \tag{3.4}$$

Svensson argues that if one assumes a neutral monetary policy where the policy rate has no long-term effect on real debt levels and thus no long-term effect on the crisis probability, then the optimal policy would not be to lean *against* the wind, but quite contrary to lean *with* the wind. The reasoning behind this statement is that if the probability of a crisis occurring at time t equals zero, it would be optimal to adjust the policy rate so that the unemployment gap equals zero. On the other hand, if there exists a positive crisis probability, then it would be optimal for the central bank to push the non-crisis unemployment rate below its equilibrium level. The reason why is the assumption that a crisis will induce a constant mark-up in the unemployment rate. In this case, the economy will be more equipped to handle a crisis since it will start from a lower unemployment rate, and thus the consequences of a crisis will be less severe.

3.2.1 Assumption of a non-neutral monetary policy

In the case of neutral monetary policy, it is obvious that leaning will not be a favourable policy in Svensson's framework since leaning will only incur costs and no gains. According

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to Svensson, leaning can only be justified if one assumes a non-neutral monetary policy where the policy rate has a sufficient negative effect on the crisis probability. He further investigates whether it is optimal with a non-crisis unemployment gap below or above zero when it is assumed that monetary policy is not neutral,

$$\frac{dp_t}{di_1} \neq 0 \text{ for } t > 1.$$

As a simplification, Svensson also assumes that the non-crisis unemployment gap equals zero for all periods,

$$E_1 \widetilde{u_t^n} = 0 \text{ for } t > 1 \tag{3.11}$$

In order to examine if an increased policy rate increases or reduces the intertemporal loss, Svensson examines the derivative of the expected intertemporal loss at time 1,

$$\frac{d}{di_1} E_1 \sum_{t=1}^{\infty} \delta^{t-1} L_t = \sum_{t=1}^{\infty} \delta^{t-1} \frac{dE_1 L_t}{di_1}$$

It would only be optimal to increase the policy rate above what is justified by an inflation targeting regime, if the derivative of the intertemporal loss with regards to the policy rate is negative.

By using equation 3.4, Svensson attains the following expression for the derivative,

$$\frac{dE_1 L_t}{di_1} = 2\left(E_1 \widetilde{u_t^n} + p_t \Delta u\right) \frac{dE_1 u_t^n}{di_1} + \left[(\Delta u)^2 + 2\Delta u E_1 \widetilde{u_t^n}\right] \frac{dp_t}{di_1} \tag{3.13}$$

If the expected non-crisis unemployment gap equals zero, the expression simplifies to,

$$\frac{dE_1 L_t}{di_1} = 2(p_t \Delta u) \frac{dE_1 u_t^n}{di_1} + \left[(\Delta u)^2\right] \frac{dp_t}{di_1} \tag{3.14}$$

The first term in equation 3.14 illustrates the loss a policy rate increase has on the unemployment gap in both non-crisis and crisis times: An increased policy rate will normally increase the non-crisis unemployment gap, which inflict an extra cost since the economy is then forced to start from a higher unemployment rate if a crisis were to occur. The second term gives the loss created by a change in the crisis probability because of the policy rate increase.

Since we know with certainty that the first term has a positive sign, the total effect on the expected welfare loss by leaning is determined by the sign in front of $\frac{dp_t}{di_1}$, and whether this effect is large enough to counteract the positive marginal loss of increasing the non-crisis unemployment rate.

Equation 3.13 can be written as,

$$NMC_t\left(E_1\widetilde{u_t^n}\right) = MC_t\left(E_1\widetilde{u_t^n}\right) - MB_t\left(E_1\widetilde{u_t^n}\right)$$

NMC is the net marginal cost of leaning, where MC is the marginal cost and MB is the marginal benefit. These three relations are illustrated in figure 3.4 when it is assumed that 3.11 holds.
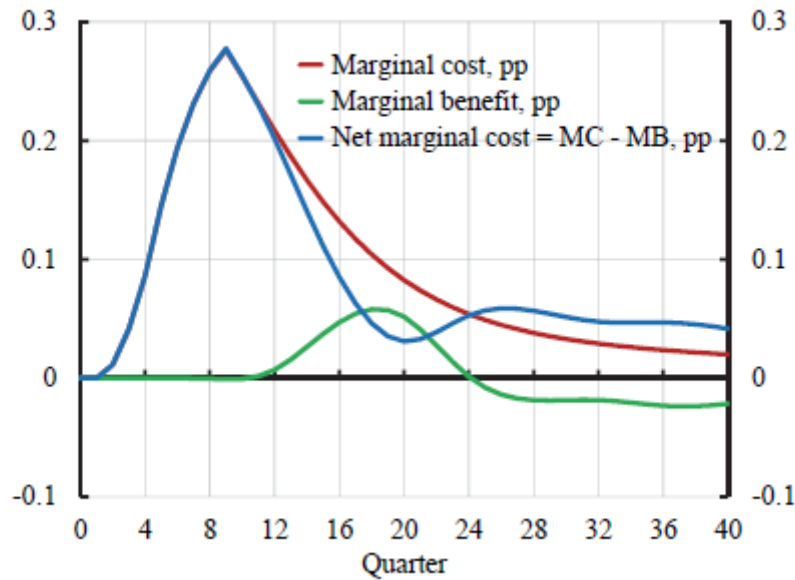
Figure 3.4: The marginal cost, marginal benefit and net marginal cost of leaning in Svensson's analysis.

The marginal benefit is proportional to $\frac{dp_t}{di_1}$. Since it has already been established by Svensson that the cumulated effect of the policy rate on the crisis probability is approximately zero, the same applies to the marginal benefit,

$$\sum_{t=1}^{40} NMC_t(0) = \sum_{t=1}^{40} MC_t(0) - \sum_{t=1}^{40} MB_t(0) \approx \sum_{t=1}^{40} MC_t(0) > 0$$

Since the policy rate has approximately zero effect on the crisis probability in the long-run, Svensson concludes that the intertemporal expected loss is increasing in the policy rate. Given this conclusion, once again it seems optimal to lean *with* the wind and not against it. Svensson

states that this conclusion is not dependent on the assumption of the expected non-crisis unemployment gap being zero. In figure 3.5, Svensson illustrates the effect of a positive non-crisis unemployment gap of 0.25 percentage points on the marginal cost and gain.

Figure 3.5: The marginal benefit, marginal cost and net marginal cost of leaning when the expected non-crisis unemployment gap is positive and equals 0.25 percentage points for all quarters (dotted lines), compared to the model with a zero unemployment gap (solid lines), in Svensson's analysis.

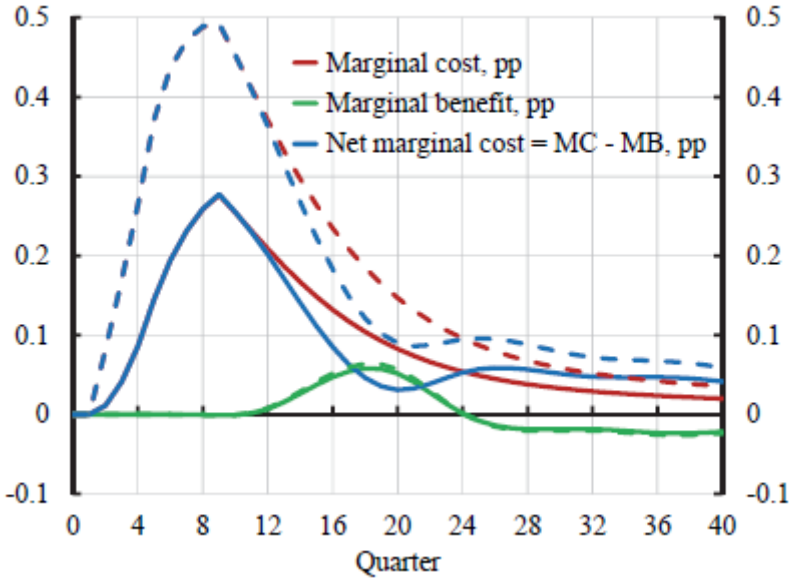The increase in the non-crisis unemployment gap leads to a rather large jump in the marginal cost of leaning. The reason why is that if a crisis occurs, then the crisis unemployment rate will now be higher than if the unemployment had been at its equilibrium level before the crisis. The increase in the non-crisis unemployment gap will on the other hand have an almost negligible effect on the marginal gain. Svensson concludes that an initial weaker economy strengthens the case *against* leaning.

Svensson also tests whether his conclusion is robust to a weaker effect on the non-crisis unemployment rate of a policy rate increase. In figure 3.6, Svensson has halved the estimated effect of a temporary policy rate increase of 1 percentage point on the unemployment in non-crisis times that was estimated by the Sveriges Riksbank. From the figure, we can see that while the marginal cost is rather heavily reduced, the marginal gains remain mostly the same as before. Even if this leads to a large downwards shift in the net marginal cost curve, we can see that the net marginal cost still remains positive in all quarters except quarters 18-21. Svensson's conclusion of leaning not being justified holds even under the assumption of a much weaker relationship between the policy rate and unemployment.
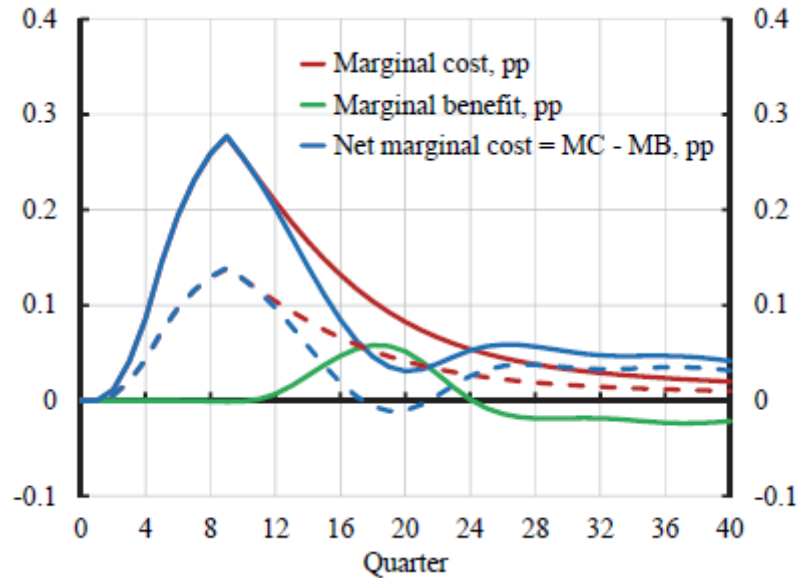
Figure 3.6: The effect on the marginal benefit, marginal cost and net marginal cost of leaning of a reduction in the effect of the policy rate on the non-crisis unemployment rate by half (dotted lines), compared to the benchmark model (solid lines).

3.3 Less efficient macroprudential policy

A common view is that macroprudential policy is the first line of defence against financial instability, while monetary policy might play a role as a second line of defence, especially in the case where the macroprudential policy is inefficient in containing the build-up of financial instability. Hence, Svensson examines whether leaning might be justified in the case of a less efficient macroprudential policy. Within his framework, there are three potential outcomes of less efficient macroprudential policies: an increased crisis probability, a larger increase in the unemployment rate in the event of a crisis, and/or a longer crisis duration.

i. **Increased crisis probability:** The baseline in Svensson's model is an annual probability of a crisis start of 3.21 %. This probability is a result of an annual credit growth rate of 5 % (see Schularick & Taylor). Svensson now assumes that the annual probability of a crisis start increases with 1 percentage point, thus the new probability is 4.21 %. This increased crisis probability is caused by a less efficient macroprudential policy, which further causes a higher credit growth. The new credit growth corresponding to the increased crisis probability is 7.9 %.

In Svensson's framework a higher q_t (probability of a crisis start in quarter t), will lead to a higher p_t (probability of the economy being in a crisis state in quarter t). Since the marginal cost of leaning is proportional to p_t, the MC curve will experience a rather large shift upwards in the diagram, while the MB curve will only experience a relatively small upwards shift through the term $\frac{dp_t}{di_1}$. From figure 3.7, we can easily see that the sum of the two shifts is an increase in the net marginal cost, which is now positive for all quarters. The conclusion is that leaning is still not justified, and that a higher crisis probability in fact strengthens the case against leaning compared to the benchmark model.
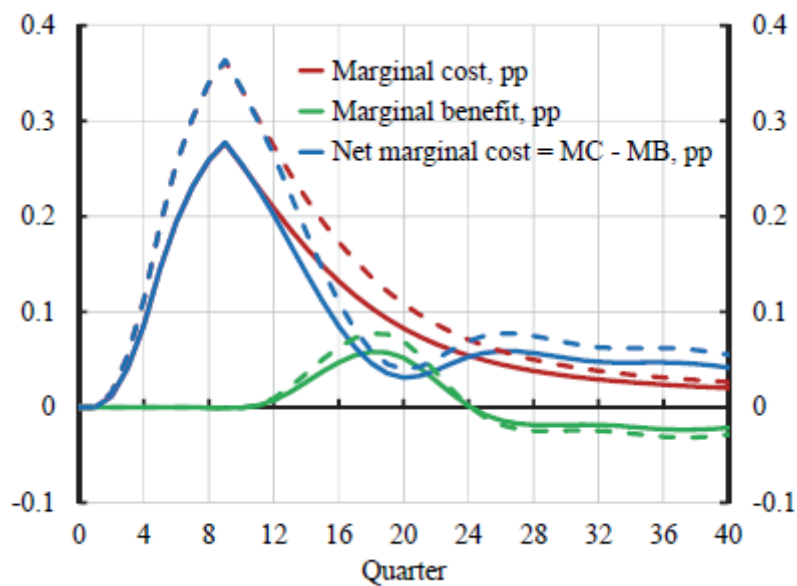
Figure 3.7: The effect of an increase in the annual probability of crisis start from 3.21 % (solid lines) to 4.21 % (dotted lines) on the marginal cost, marginal benefit and net marginal cost of leaning.

ii. **A higher increase in the unemployment rate in the event of a crisis**: The baseline in Svensson's model is that a crisis will induce a fixed increase in the crisis unemployment rate (Δu) by 5 percentage point. Svensson assumes that a less efficient macroprudential policy will lead to a higher fixed increase in the unemployment rate by 1 percentage point. The cost of a crisis in terms of unemployment is now assumed to be a 6-percentage point increase in the crisis unemployment rate.

From equation 3.13 above we can see that while the marginal cost in linear in Δu, the marginal benefit is quadratic in Δu. The result is that a less efficient macroprudential policy in this case will lead to an increase in both the marginal cost and marginal

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benefit, thus both curves will shift upwards. In figure 3.8, we can see that the net effect is an increase in the net marginal cost in all quarters except 19. The conclusion is again that a less efficient macroprudential policy do not contribute to the justification of leaning.
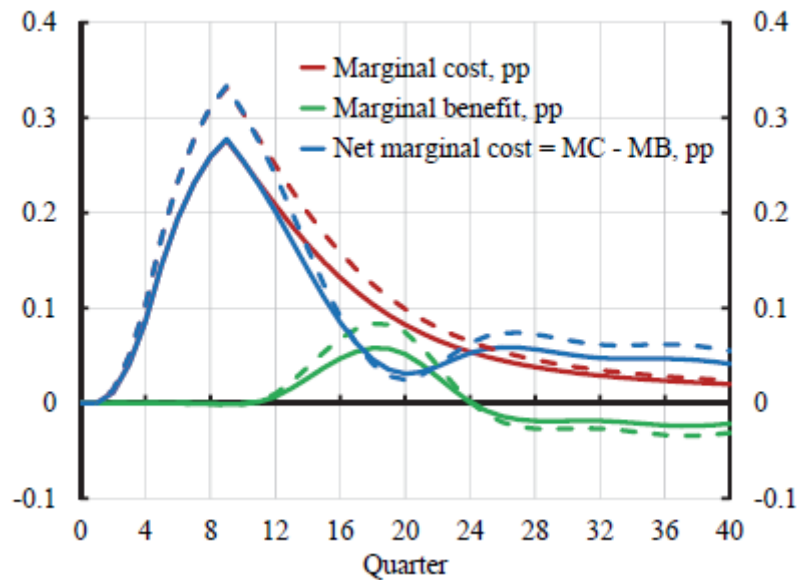
Figure 3.8: The effect of an increase in the crisis increase in the unemployment rate from 5 (solid lines) to 6 percentage points (dotted lines) on the marginal cost, marginal benefit and net marginal cost of leaning, in Svensson's analysis.

iii. **Increased crisis duration:** The baseline in Svensson's model is that a crisis will last 8 quarters. He now assumes that a less efficient macroprudential policy will cause crisis to last longer. More specifically, he assumes that they will now last for 12 quarters.

A longer crisis duration implies, in Svensson's framework, that the probability of being in a crisis at quarter t (p_t) now equals the sum over four additional quarter wise probabilities of a crisis start. The result of this is that both the marginal cost curve and marginal benefit curve shift to the right. The net effect of a longer crisis duration is that the net marginal cost of leaning increases for all quarters except quarter 24 where the marginal benefit somewhat outweighs the marginal cost. Neither in this case of a less efficient macroprudential policy, is leaning justified.

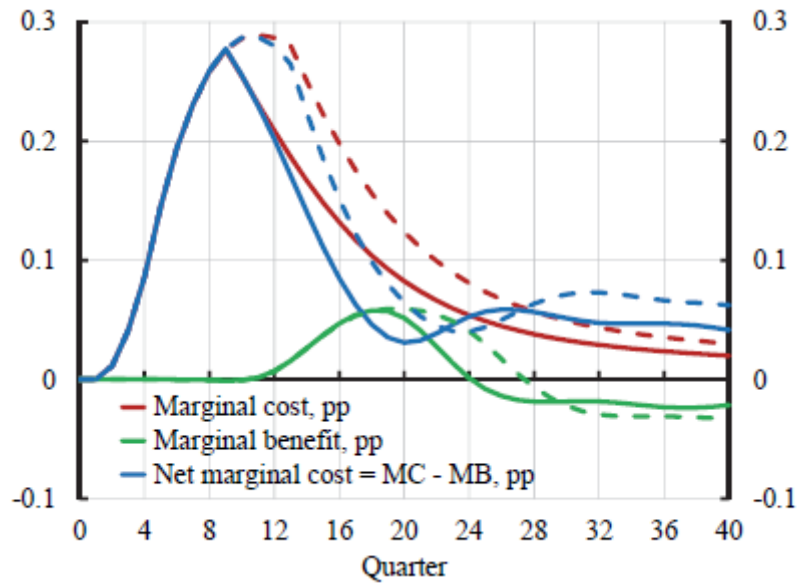**Figure 3.9**: The effect of an increase in the crisis duration from 8 (solid lines) to 12 quarters (dotted lines) on the marginal cost, marginal benefit and net marginal cost of leaning, in Svensson's analysis.

Svensson concludes that a less efficient macroprudential policy do not strengthen the argument for leaning. Quite contrary, Svensson concludes that a less efficient macroprudential policy actually strengthens the argument *against* leaning as seeing that in all the three cases above, a less efficient macriprudential policy leads to an increase in the net marginal cost of leaning.

3.4 Non-neutral monetary policy – a permanent effect on real debt

The reason why leaning is not justified in Svensson's framework, is because of the absence of a long-term effect on the crisis probability of monetary policy. A policy rate increase causes a high increase in the non-crisis unemployment, while having approximately no marginal benefits in the form of reduced crisis probability. A common idea is that if monetary policy in fact is not neutral in the long run, then the policy rate might be capable of affecting the crisis probability sufficiently for leaning to become justified. Svensson examines this claim by adjusting the estimated effect on the real credit level of a temporary increase in the policy rate.

The baseline is estimates from the Sveriges Riksbank, which found that a temporary increase in the policy rate initially leads to a fall in the real credit level, but after 7 quarters the real credit level will start converging back to its baseline. The net effect of the policy rate increase

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on the credit growth is approximately zero in the long run. Svensson now assumes that the policy rate increase has a permanent effect on the real credit level, meaning that the credit level stays down at its maximum deviation from baseline. This implies a reduction in the real credit level of 1.03 percentage points from quarter 8 and onwards, illustrated in figure 3.10. Since the policy rate increase now leads to a permanent reduction in the real credit level, the net effect on credit growth becomes negative, thus leading to a decrease in the crisis probability. Though relative large in magnitutde compared to the benchmark model, the decrease in the crisis probability is not permanent as the crisis proability eventually converges back to its baseline.
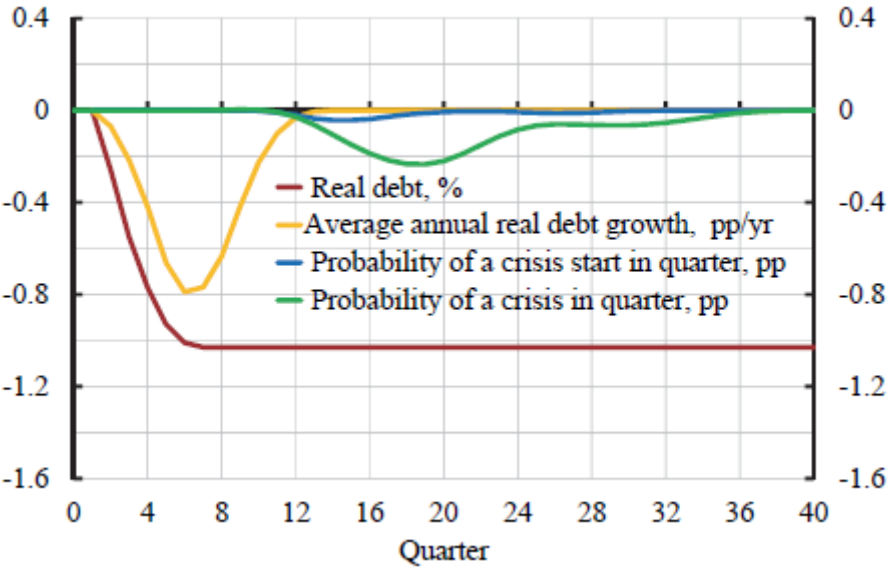
Figure 3.10: A permanent effect of the monetary policy shock on credit and the crisis probabilities, in Svenssons' analysis.

The reduction in the crisis probability has a large positive effect on the marginal benefit, which causes the marginal benefit curve to shift upwards, as seen in figure 3.11 below. However, the shift in the marginal benefit is not large enough to sufficiently counteract the marginal cost, hence the conclusion is still that the net marginal cost is positive in all quarters.

Svensson concludes that even under a non-neutral monetary policy, leaning will still not be justified. He further concludes that in order to achieve a result where the marginal benefits of leaning otweighs the marginal cost, not only is it required with what he calls an extreme assumption about non-neutral monetary policy, but it is also required an extreme assumption about the magnitude of the effect of the policy rate on the crisis probability[2].

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[2] In order for leaning to be justified in the case on non-neutral monetary policy, the magnitude of the policy rate on the crisis probability must be 5.8 times larger than estimated by Sveriges Riksbank.

Figure 3.11: The marginal cost, marginal benefit and net marginal cost of leaning when the monetary policy rate has a permanent effect on credit and the crisis probabilities in Svensson's analysis.
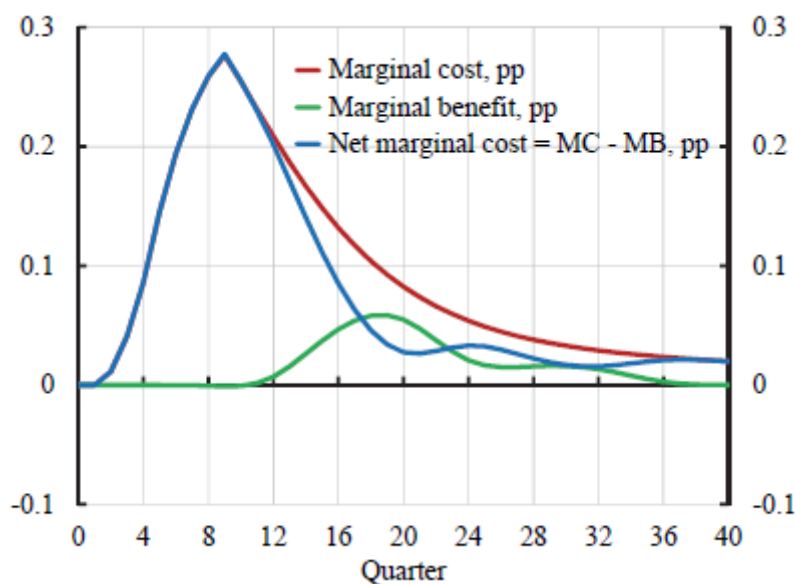
3.5 Conclusion

Svensson claims that it is mainly through credit growth that it is empirically established that the policy rate can affect the crisis probability. However, if monetary policy is neutral in the long run, then a policy rate increase will not have any effect on the accumulated credit growth in the long run. A potentially lower credit growth and thus a lower crisis probability in some quarters, will be followed by a higher credit growth and thus also a higher crisis probability in subsequent quarters. The net effect of leaning is simply a higher unemployment rate, both in non-crisis and crisis times.

Advocates of leaning have claimed that monetary policy becomes more important in maintaining financial stability in the case of inefficient macroprudential policy. Svensson test this claim by examining the robustness of his result in the case of a higher crisis probability, a longer crisis duration, and a higher crisis induced increase in the unemployment rate. He finds that in all cases, the marginal cost of leaning still dominates the marginal benefits.

Another common view among supporters of leaning is that leaning will be justified in the case of a non-neutral monetary policy. A permanent reduction in the real credit level caused by a temporary increase in the policy rate, does in fact lead to a somewhat prolonged reduction in the crisis probability within Svensson's framework. This will further lead to a small increase in the marginal benefit of leaning, but without extreme assumptions about the magnitude of

the effect of the policy rate on the crisis probability, the increase in the marginal benefit will not be sufficient to neutralize the marginal cost of leaning.

4 The benchmark model

In this chapter, Svensson's cost-benefit analysis of leaning is calculated for Norwegian estimates. The analysis below largely follows Svensson's analysis with the exception of utilizing a different sample country and a different estimation technique in order to estimate the monetary policy shock, namely VAR estimation. Readers interested in the construction of the dataset and the VAR model is referred to appendix 1. Chapter 7 clarifies whether the difference in the results between my benchmark model and Svensson's is caused by the use of different sample country, or the use of different estimation techniques. There are some evidence that the assumption of a 1-pecentage point increase in the policy rate is not representative for how central banks implement leaning. In reality, the average "leaning-type" central bank will increase the policy rate by 0.3 percentage points, above what is mandated by inflation and output stability concerns (see Friedrich, Hess & Cunningham 2015). Nevertheless, this thesis follows Svensson and assumes a monetary policy shock of 1-pecentage point increase in the policy rate.

4.1 Development in the expected future unemployment rate

Svensson initially analyses leaning by examining how an unexpected monetary policy shock today, affects the expected future unemployment rate for the following 40 quarters. The effect of leaning on the expected future unemployment rate is given by the expression below. As we can see, the total effect is determined by the increase in the expected future non-crisis unemployment rate following a policy rate increase, and the effect the same policy rate increase has on the probability of a crisis in quarter t. These two effects are examined below.

$$\frac{dE_1 u_t}{di_1} = \frac{dE_1 u_t^n}{di_1} + \Delta u \frac{dp_t}{di_1} \tag{1.1}$$

From the VAR analysis, I find the estimated impulse response function for the unemployment rate after a policy rate shock. The impulse response is illustrated below for the following 40 quarters after the shock. The unemployment rate increases until it reaches 0.7 percentage point above baseline around quarter 7, and then gradually falls. This is largely in line with the result Svensson found using the Sveriges Riksbank's DSGE model. The unemployment rate

will eventually reach its baseline level around quarter 17, where it will somewhat fluctuate around its baseline throughout the remaining quarters[3].

The red graph in figure 4.1 defines the development in the expected future *non-crisis* unemployment rate. In order to find the development in the expected future *crisis* unemployment rate, two relations must be defined: the effect of a policy rate increase on credit growth, and the effect of credit growth on the crisis probability. The first relation is found from the impulse response function for the credit growth from the VAR model. Further, I follow Svensson and find the second relation by utilizing the crisis probability function developed by Schularick & Taylor (2012).
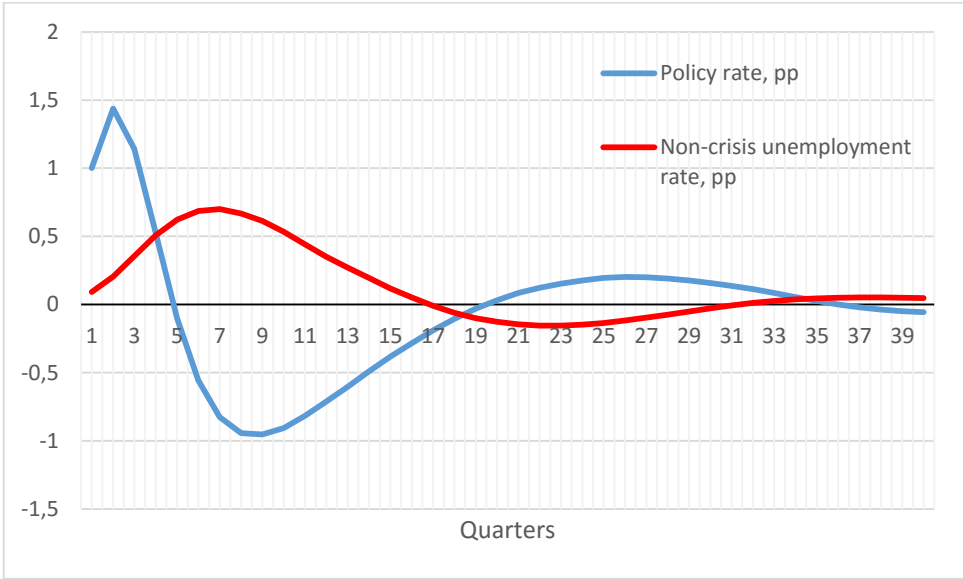
Figure 4.1: The effect of the monetary policy shock on the policy rate and the non-crisis unemployment rate, in the benchmark model.

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[3] In similarity with Svensson, I find that the policy rate must fall below its baseline after the initial monetary policy shock. This is in line with an inflation targeting regime: in order to reach the inflation and output targets, any deviation from the policy rate path today must be met by similar adjustments (but with opposite sign) in the future.
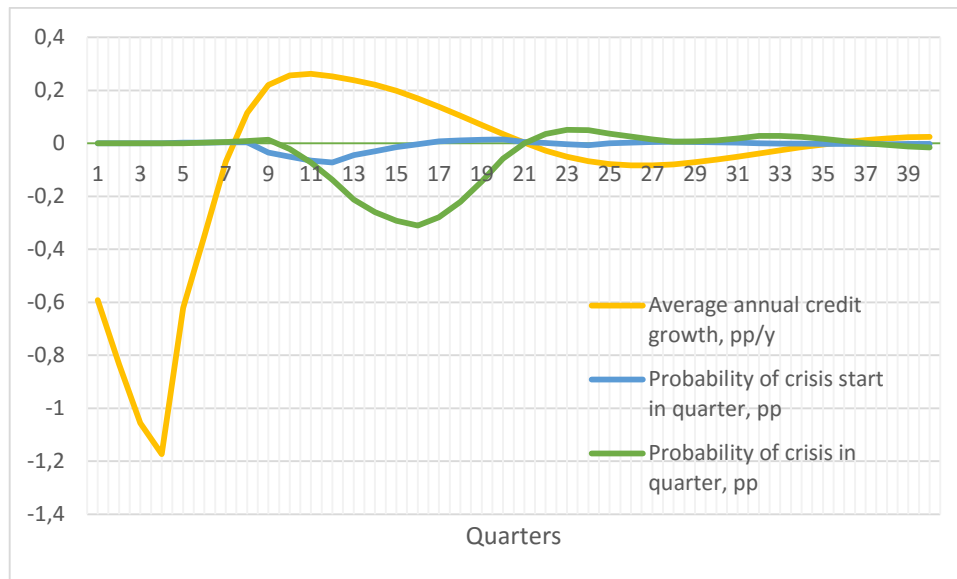
Figure 4.2: The effect of the monetary policy shock on the average annual credit growth and the crisis probabilities, in the benchmark model.

In figure 4.2, I illustrate the effect of the temporary increase in the policy rate on the average annual real credit growth, on the probability of a crisis start in quarter t, and on the probability of the economy being in a crisis in quarter t. All estimates are measured as deviations from their baselines in percentage points[4].

Svensson finds that monetary policy is neutral in the long run, which leads to an equally large increase in the credit growth above its baseline after the initial fall. I too find that the decreasing effect on the credit growth is followed by an increase above its baseline. However, the increase in the credit growth around quarter 7 is by far outweighed by the initial fall in credit growth following the monetary policy shock. The maximum decrease in the credit growth is also somewhat larger than the initial decrease Svensson found, approximately 1.2 percentage point compared to 0.8 percentage point decrease from baseline. These two differences from Svensson's result on credit growth, lead to an accumulated decrease in the crisis probabilities in my analysis. As opposed to Svensson, I do not find that the initial fall in the crisis probabilities is followed by an equally large increase above its baseline within the 40 quarters horizon. Instead, the probability of a crisis in quarter t falls as low as 0.3 percentage point below its baseline (compared to a maximum fall of 0.2 percentage point found by Svensson) before gradually converging back to its baseline.

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[4] Baseline for annual credit growth is estimated as the average annual credit growth in the data set, which is approximately 6.57 %. Given the estimates for annual credit growth, the estimated baseline for the probability of a crisis start in quarter t is 0.93 %. Since the probability of the economy being in a crisis at quarter t is the sum of the probabilities of a crisis start in the 7 previous quarter, estimated baseline probability for a crisis in quarter t is 6.51 %.

The two terms in equation (1.1) are now found, and for now, I follow Svensson in assuming that the cost of a crisis is a fixed increase in the unemployment rate by 5 percentage point. The development in the expected future unemployment rate and the expected future non-crisis unemployment rate for the following 40 quarters after the monetary policy shock is illustrated in figure 4.3 below. The expected future non-crisis unemployment rate is identical to the impulse response for the unemployment rate, while the expected future unemployment rate also includes the product of the crisis-induced increase in the unemployment rate and the reduced crisis probability following the policy rate increase.

In Svensson's analysis, the expected future unemployment rate largely coincides with the development in the future expected non-crisis unemployment rate. This is caused by the lack of long run effects of monetary policy on credit growth, and thus the lack of long run effect on the crisis probabilities. I find, on the other hand, that the expected future unemployment rate only coincides with the increase in the non-crisis unemployment for the first 10 quarters. It then gradually falls and becomes negative. In other words, the monetary policy shock causes only a small initial increase in the expected future unemployment rate, followed then by a significantly larger decrease in the unemployment rate. This result is in sharp contrast to Svensson's, which found an increase in the expected future unemployment rate for all 40 quarters.
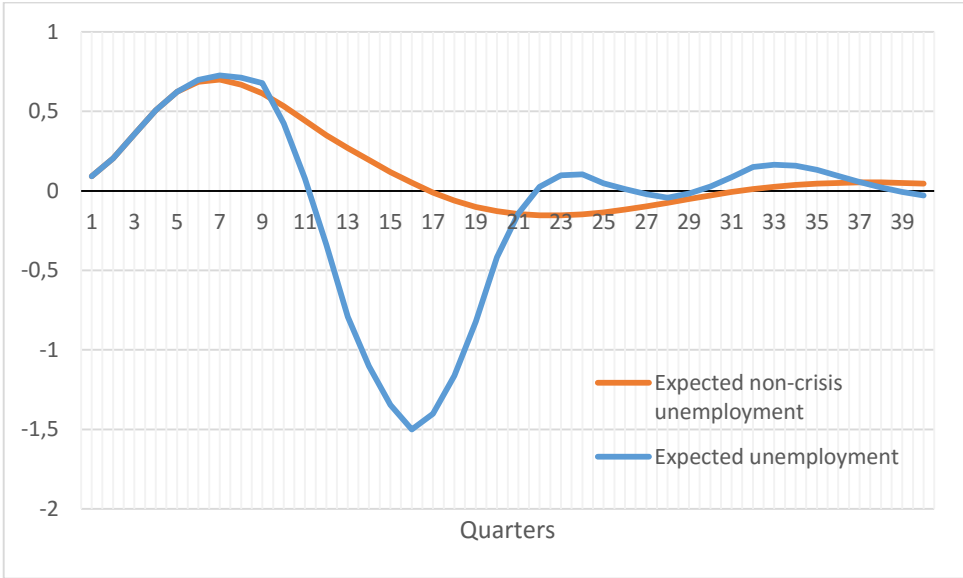

Figure 4.3: The effect of the monetary policy shock on the expected future unemployment rate, in the benchmark model.

4.2 Quadratic loss function

So far, I have found that leaning causes only an initial increase in the expected future unemployment rate, followed by a larger drop. Nevertheless, it is also necessary to evaluate leaning by the use of a formal loss function. I adopt Svensson's approach of evaluating the intertemporal loss over the next 40 quarters using a quadratic loss function,

$$E_1 \sum_{t=1}^{\infty} \delta^{t-1} L_t = \sum_{t=1}^{\infty} \delta^{t-1} E_1 L_t$$

where δ is the discounting factor, and L_t is the loss function given by,

$$L_t = (\widetilde{u_t})^2$$

Given the assumption of an expected non-crisis unemployment gap equal to zero, it was found that the effect of leaning on the welfare loss is given by the following expression,

$$\frac{dE_1 L_t}{di_1} = 2(p_t \Delta u) \frac{dE_1 u_t^n}{di_1} + [(\Delta u)^2] \frac{dp_t}{di_1}$$

As discussed in the summery of Svensson's analysis, the first term in the expression above gives the marginal cost of leaning, while the second gives the marginal benefit. Not surprisingly, Svensson finds that the net marginal cost of a temporary policy rate increase largely coincides with the marginal cost. This is due to the absence of a long-term effect on the crisis probabilities of monetary policy, which leads to no long-term marginal benefits of leaning, only marginal costs. By using my estimates in the expression above, I find the following development in the marginal cost, marginal benefit, and net marginal cost of leaning in Norway.
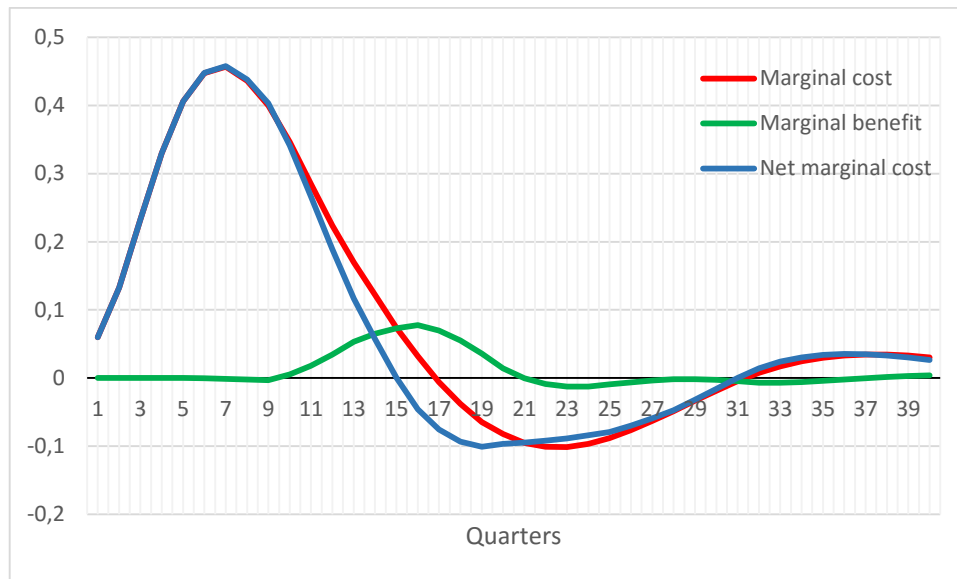
Figure 4.4: The marginal cost, marginal benefit and net marginal cost of leaning in the benchmark model.

As Svensson, I find that the net marginal cost initially follows the developments in the marginal cost. However, the net marginal cost gradually decreases and becomes negative after 15 quarters, caused by the positive marginal benefit. In other words, I do find a positive and increasing net marginal cost following the monetary policy shock, but as the marginal benefit becomes positive because of a decreasing crisis probability, the net marginal cost also decreases and becomes negative. However, the negative net marginal cost in quarters 15-31 is not large enough to counteract the positive net marginal cost in the remaining quarters, especially not when the discount rate is taken into account[5]. Because of the positive accumulated net marginal cost, leaning is not justified in my benchmark model either since the benefit is outweighed by the cost.

4.3 Sensitivity analysis

Svensson examines the robustness of his results by an array of scenarios in his sensitivity analysis. He examines the effect on the marginal cost and marginal benefits of leaning in the following scenarios:

i. A positive non-crisis unemployment gap of 0.25 percentage points.

ii. The effect of the policy rate increase on the non-crisis unemployment rate is halved.

iii. The annual probability of a crisis start in the absence of leaning is 1 percentage point higher.

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[5] The accumulated net marginal costs over the 40 quarters is in fact 3.07. Since the benefit of leaning is collected in the future, while the cost is paid now, discounting will increase the accumulated net marginal cost.

iv.   The cost of a crisis increases from a 5- to a 6-percentage point increase in the unemployment rate.

v.   The duration of a crisis increases from 8 to 12 quarters.

Sensitivity analyses iii.-v. implies a less efficient macroprudential policy, and it is meant to examine the popular statement that leaning is more justified in the case of inefficient macroprudential policy. The reader is referred to appendix 3 for illustrations of the effect the different scenarios has on the benefit and cost of leaning, compared to the benchmark model.

Svensson finds that in all the above scenarios, leaning is still not justified (see the summary of Svensson's analysis for the specific results of each of the scenarios). The conclusion that leaning is not justified is also robust to all the sensitivity analyses above in my benchmark model as well. This is especially the case when there is a positive non-crisis unemployment gap of 0.25 percentage points (i.), or an increased crisis duration (v.). Both scenarios have a large impact on the marginal cost of leaning (and only a modest effect on the marginal benefit), and thus they lead to a rather large increase in the accumulated net marginal cost compared to the benchmark model[6]. Both a higher annual probability of a crisis start (iii.) and increased cost of a crisis (iv.), lead to an increase in the marginal cost and the marginal benefit, though the increase in the marginal cost dominates the increase in the marginal benefit. However, the increase in the accumulated net marginal cost is relatively modest[7].

The only scenario that reduces the accumulated net marginal cost is when the effect of the monetary policy shock on the non-crisis unemployment rate is halved (ii.). Since the marginal cost of leaning is proportional to the effect of the policy rate increase on the unemployment rate, halving the impulse responses from the VAR estimation leads to a large drop in the marginal cost in all quarters. The marginal benefit is, on the other hand, unaffected by this adjustment and remains the same. The result is a large decrease in the net marginal cost. Nevertheless, the accumulated net marginal cost remains positive and leaning is still not justified[8].

In Svensson's framework, a less efficient macroprudential policy has a positive effect on the marginal benefit of leaning. This is a result of financial crises now being more severe and thus the desirability of avoiding such crises has increased. Perhaps surprisingly, a less efficient macroprudential policy also leads to an increased marginal cost of leaning. This effect is

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[6] The accumulated net marginal cost is now 5.72 and 4.86, respectively.
[7] The accumulated net marginal cost is now 3.84 and 3.58, respectively.
[8] The accumulated net marginal cost is now 1.33.

caused by the assumption of a fixed cost of crises. Since a crisis leads to a fixed increase in the unemployment rate, it is better for the economy to start out at the lowest possible non-crisis unemployment rate. Leaning causes an increase in the non-crisis unemployment rate, and if a crisis were to occur after the central bank leaned, the total increase in unemployment will be larger than if the bank had not leaned. When the severity of a crisis is magnified as a result of a less efficient macroprudential policy, this additional cost of leaning is also magnified.

4.4 Conclusion

In conclusion, leaning cannot said to be justified in my benchmark model when the cost and benefit of leaning is measured by the quadratic loss function in Svensson (2015). Contrary to Svensson though, I do find that leaning has a substantial marginal benefit; it is however generally not large enough to counteract the increase in the non-crisis unemployment rate that follows a monetary policy shock. This conclusion holds for all of the scenarios in Svensson's sensitivity analysis. The only scenario that caused a reduction in the accumulated net marginal cost was halving the estimated impulse responses of unemployment to the policy rate increase. Even though the marginal benefit increased in some of the other scenarios, the increase in the marginal cost was larger, thus increasing the accumulated net marginal cost. In conclusion, leaning is justified neither in my benchmark model nor in the alternative scenarios in the sensitivity analysis. Furthermore, these results have not been adjusted to include discounting, and since discounting will put a larger weight on the cost of leaning than on the benefits (because the benefits are collected in the future, while the cost are paid now), discounting will make leaning even *less* justified.

Wide confidence bands in the estimates from the VAR model, causes some uncertainty in the results from the benchmark model. The reader is referred to appendix 3 for the analysis with the use of the upper and lower bound from a 67 % confidence bands, as opposed to the median estimates used in the analysis above. Although the use of the 67 % confidence bands produces a rather different development in the marginal benefit and cost than in the benchmark model, the conclusion is still the same as in the benchmark model: leaning costs more than it benefits.

5 The effect of high and low credit growth

Svensson has to some extent examined the effect of increased credit growth on the cost and benefit of leaning. When testing the popular statement that a less efficient macroprudential policy justifies leaning, he examined the effect of a higher baseline crisis probability (which is ultimately caused by a higher credit growth) on the cost and benefit of leaning. Not only did he find that leaning was still not justified in this scenario, but he even found that leaning was *less* justified in the sense that the net marginal cost of leaning had increased compared to the benchmark model. In this section, I give a more systematic and closer view on the effect of a higher/lower credit growth on the cost and benefit of leaning within Svensson's framework.

5.1 High credit growth

In the benchmark model, it was assumed a quarterly credit growth of 1.6 % as baseline (this was the average quarterly credit growth in the sample), in the absence of leaning. This implied a probability of a crisis starting in any given quarter, and a probability of the economy already being in a crisis, of 0.93 % and 6.5 %, respectively. It is now assumed that the quarterly credit growth is 1 percentage point higher than in the benchmark model. A quarterly credit growth of 2.6 % means that baseline probability of crisis start, and baseline probability of an already existing crisis in any given quarter, has now increased to 1.38 % and 9.65 %, respectively. Figure 5.1 below illustrates the effect of the same monetary policy shock on credit growth and crisis probabilities for this higher baseline credit growth.

The deviation in the average annual credit growth, caused by the policy shock, is approximately the same as in the benchmark model: average annual credit growth drops almost 1.2 percentage points below baseline. It then increases somewhat above baseline, before gradually converging back to baseline. The increased baseline credit growth does, however, cause a downwards shift in the crisis probabilities. This increased effect on the crisis probability is caused by the logit model Schularick & Taylor (2012) use to estimate the effect of credit growth on the crisis probability. A logit model is non-linear, meaning in this case that the positive relationship between credit growth and the crisis probability is increasing in the initial level of credit growth. The monetary policy shock causes the probability of the economy being in a crisis at any given time to fall with as much as 0.46 percentage point below its baseline, compared to the 0.3 percentage point reduction found in the benchmark model. The accumulated effect of the monetary policy shock on the probability of crisis in

quarter t is now -2.47 percentage points, compared to -1.65 in the benchmark model[9]. In other words, the effect of leaning on the crisis probability is larger when the initial credit growth is high, compared to when it is low.

Figure 5.1: The effect of higher credit growth on average annual credit growth and the crisis probabilities (dotted lines), compared to the benchmark model (solid lines).

Figure 5.2:The effect of higher initial credit growth on the marginal cost, marginal benefit and net marginal cost of leaning (dotted lines), compared to the benchmark model (solid lines).

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[9] Mathematically, this can be expressed as $\sum_{t=1}^{40} \frac{dp_t}{di} = $ -2.47 percentage points, compared to $\sum_{t=1}^{40} \frac{dp_t}{di} = $ -1.65 in the benchmark-model.

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In Svensson's framework, the benefit of leaning is a product of the effect of the policy rate on the crisis probability. Since the accumulated reduction in the crisis probabilities increases when credit growth is high, also the marginal benefit of leaning will increase. In figure 5.2 above, we can see that a higher credit growth causes an upwards shift in the MB-curve.

However, the marginal cost of leaning is a function of the actual level of the crisis probability. A higher credit growth causes a higher crisis probability, and thus the cost of leaning will now be higher. As explained previously, there are two costs of leaning. A temporary monetary policy shock today will increase the non-crisis unemployment rate in the short run. This is the standard cost. However, leaning has an additional cost in the sense that if a crisis were to occur in the time after the shock when the non-crisis unemployment rate is above baseline, then the total crisis-unemployment rate will be higher than in the case where the central bank did not lean. This additional cost is based on the assumption of a fixed increase in the crisis unemployment rate. A higher credit growth, and thus higher crisis probability, increases this additional cost of leaning, since it is now more likely that a crisis will occur and that the economy will switch to the higher crisis unemployment rate.

A higher quarterly credit growth of 1 percentage point, compared to the benchmark model, causes an upward shift in both the marginal cost and the marginal benefit of leaning. The increase in the marginal benefit is relatively modest compared to the large increase in the marginal cost. The net effect is an increase in the accumulated net marginal cost[10]. Not surprisingly, the conclusion from Svensson's sensitivity analysis is upheld: leaning is less justified in the case of a higher credit growth.

5.2 Low credit growth

It is now assumed a quarterly credit growth that is 1 percentage point below baseline in the benchmark model, which means that baseline credit growth is now assumed to be a modest 0.6 %. A decrease in the credit growth also means that baseline crisis probabilities have decreased: the probability of crisis start in any given quarter, and the probability of an existing crisis in any given quarter, are now 0.63 % and 4.4 %, respectively. Figure 5.3 illustrates the effect of the monetary policy shock on credit growth and crisis probabilities for this lower baseline credit growth.

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[10] The accumulated net marginal cost of leaning is now 4.54, compared to 3.07 in the benchmark model.
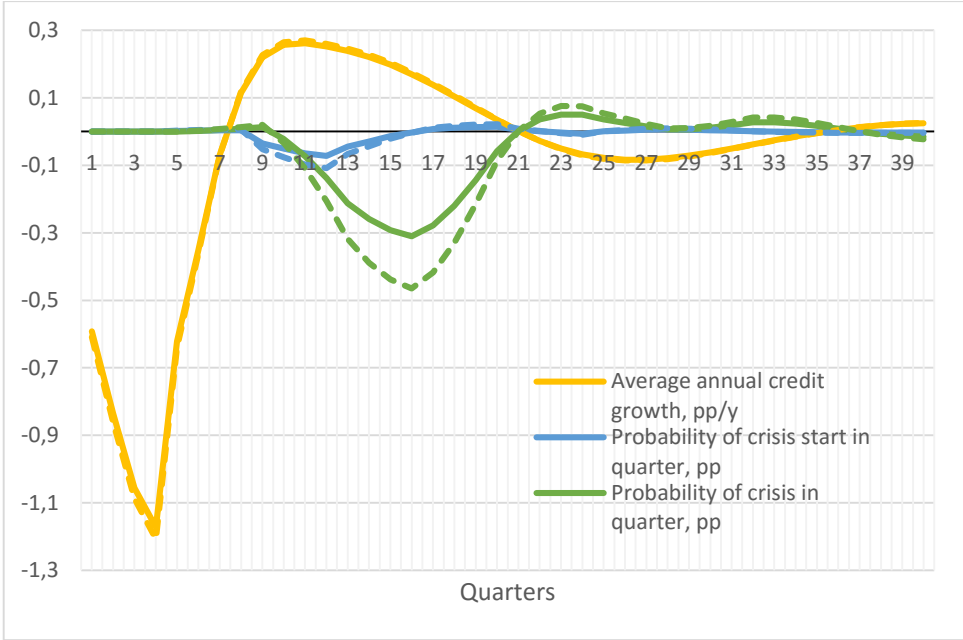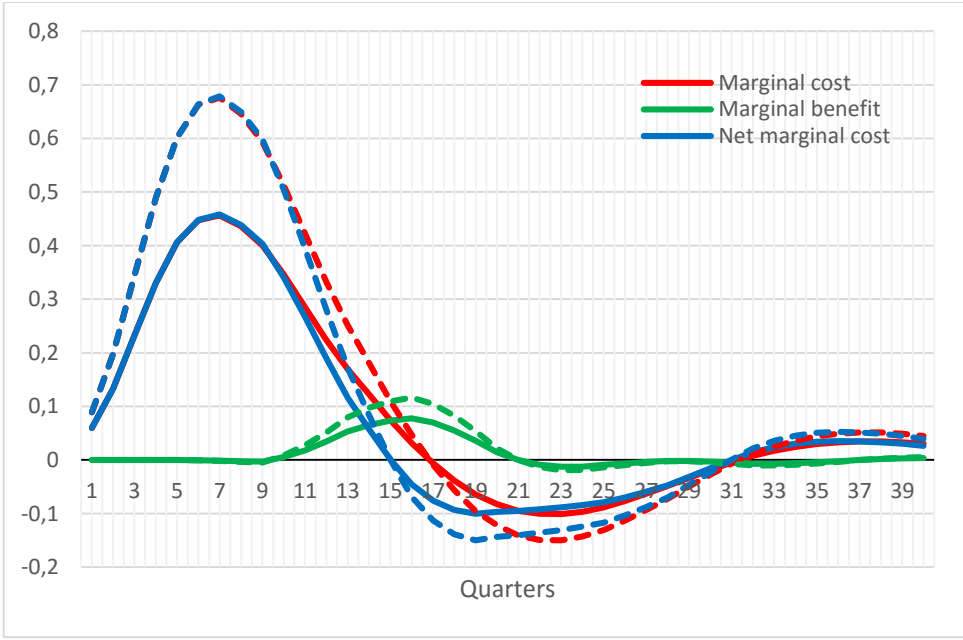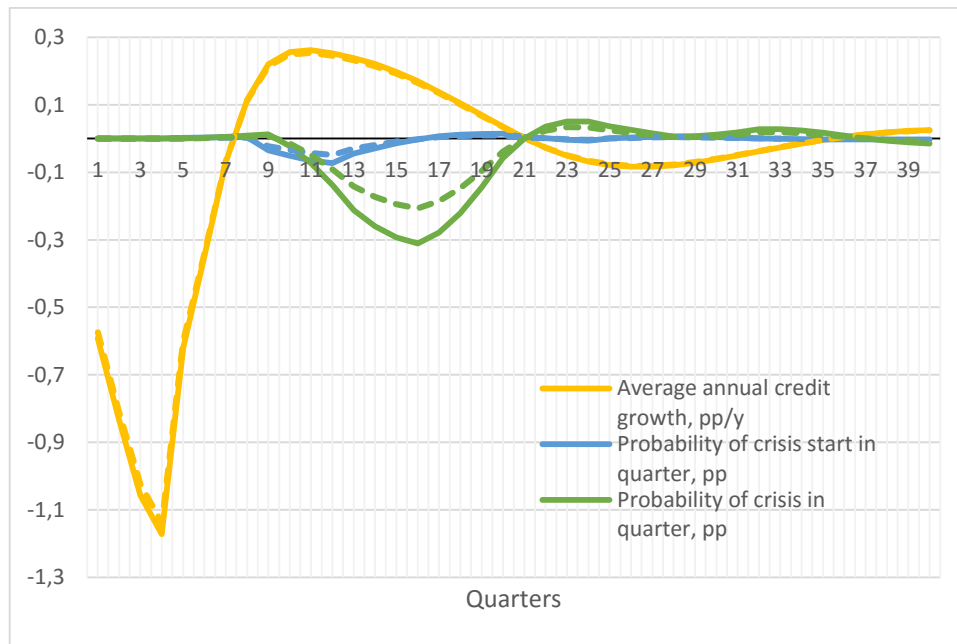
Figure 5.3: The effect of a lower initial credit growth on the average annual credit growth and the crisis probabilities (dotted lines), compared to the benchmark model (solid lines).

As in the case with a higher credit growth, a lower baseline credit growth does not lead to any significant changes in the deviation in the average annual credit growth caused by the monetary policy shock. On the other hand, the deviations in the crisis probabilities from their baselines are affected by the smaller baseline credit growth. The monetary policy shock still causes the probability of the economy being in a crisis in any given quarter to drop below its baseline, but the reduction is now smaller with a maximum deviation of 0.2 percentage points, compared to 0.3 percentage points in the benchmark model. The reason for this smaller reduction in the crisis probability is the same as above: in the logit model, the effect of a reduction in credit growth on the crisis probability is smaller when the economy starts out at a lower level of credit growth. The accumulated effect of the changes in the credit growth on the probability of the economy being in a crisis is now reduced to -1.1 percentage points, compared to the -1.65 percentage points reduction in the benchmark model.

The smaller accumulated effect on the crisis probabilities over the 40 quarters following the monetary policy shock cause a reduction in the benefit of leaning, hence there is a downwards shift in the MB-curve, as seen in figure 5.4. However, the largest impact of a lower credit growth is found to be on the cost of leaning. The lower credit growth has a relatively larger impact on the actual level of the crisis probabilities, than it has on the derivative of the probabilities with regards to the policy rate. This results in a significant reduction in the marginal cost of leaning.
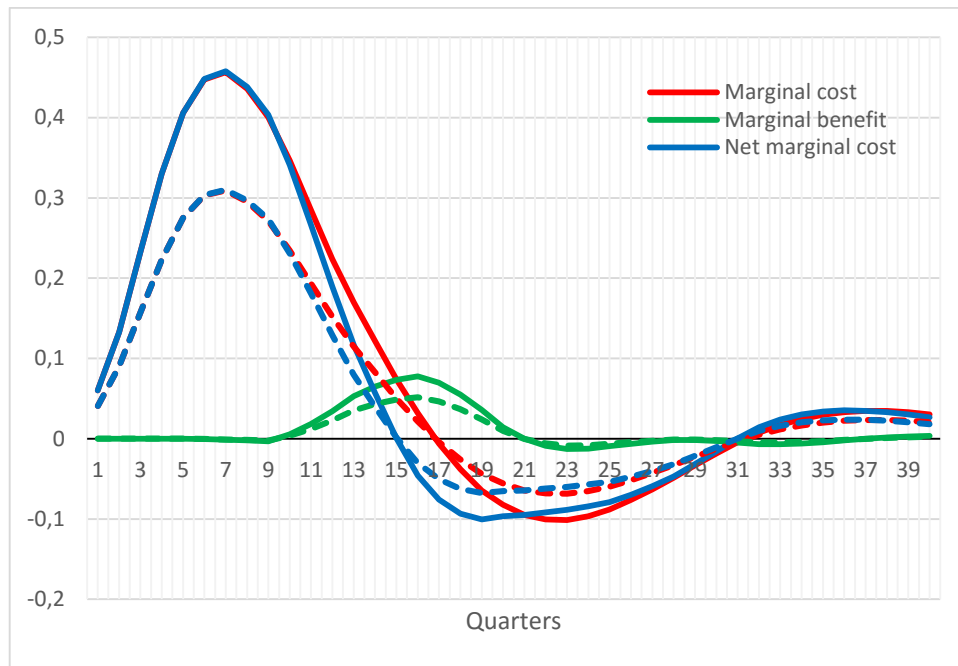
Figure 5.4: The effect of a lower initial credit growth on the marginal cost, marginal benefit and net marginal cost of leaning (dotted lines), compared to the benchmark model (solid lines).

Even though both the marginal benefit and cost of leaning is reduced when the initial level of credit growth is reduced, the reduction in the marginal benefit is by far outweighed by the reduction in the marginal cost. This causes a decrease in the net marginal cost of leaning for all quarters, except in quarters 15-32 where there is a small increase. Nevertheless, the end result is a decrease in the accumulated net marginal cost. However, the accumulated net marginal cost is still positive, meaning that even though leaning is *more* justified in this scenario with a lower baseline credit growth, it still cannot said to be justified in the sense of having a larger benefit than cost[11].

5.3 Conclusion

The aim of this section was to clarify the dilemma inherent in Svensson's framework for analysing leaning. In Svensson's framework, a higher initial level of credit growth will create a larger marginal benefit of leaning. This effect is caused by the non-linear logit probability model, which gives a larger reduction in the crisis probability of increases in the policy rate when credit growth is already high. This effect has been illustrated above by assuming a quarterly credit growth that is 1 percentage point above and below baseline in the benchmark model. It has been shown that the marginal benefit curve shifts upwards in the case of the

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[11] The accumulated net marginal cost is now 2.08, compared to 3.07 in the benchmark model.

higher credit growth, while it shifts downwards in the case of the lower credit growth. However, in Svensson's framework, also the marginal cost of leaning is increasing in the level of credit growth, since it now is much more likely that the economy will be struck by a crisis, which will trigger a fixed increase in the unemployment rate. Both the marginal benefit and the cost are products of the crisis probability, but while the first is a product of the derivative with regards to the policy rate, the latter is a product of the actual level. This means that an increase in the benefit of leaning caused by a higher credit growth will always be outweighed by the increase in the cost. The dilemma is that in times of high credit growth, when arguably leaning is most needed, is also when the cost of pursuing leaning is highest.

6 The relationship between the crisis cost and leaning

A common assumption in cost-benefit analyses of leaning is to assume that a financial crisis has a fixed cost, measured as a fixed increase in the unemployment rate. Svensson's analysis is no exception; it assumes a 5-percentage point increase in the unemployment rate in the event of a crisis. Even though the level of this fixed increase in unemployment may seem somewhat arbitrary, there are some existing evidence to justify this assumption (see Claessens, Klose & Terrones 2010). However, new research has uncovered an additional relationship between credit growth and financial instability: not only can excessive credit growth be a source of financial instability, but excessive credit growth can also exacerbate the consequences of financial crises. Research by Jorda, Schularick & Taylor (2013) has shown how recessions accompanied by financial crises generally lead to a more severe drop in aggregated output than regular recessions, and more importantly; high levels of credit growth before the crisis will lead to an additional drop in output. This additional effect of credit growth is especially strong in the case of financial crises.

The implication of these new findings is that it would be erroneous to assume a fixed cost of crises. Previously, leaning had only one benefit through its effect on the crisis probability. If excessive credit growth in fact leads to a higher drop in output, and thus an increase in unemployment, then leaning has an additional benefit through its effect on the crisis cost. A temporary increase in the policy rate will reduce credit growth, and as previously this will reduce the crisis probability, but it will also reduce the cost if a crisis were occur. This means that the assumption of a fixed cost will most likely lead to a bias in the analysis by understating the marginal benefit, as well as overstating the marginal cost, of leaning.

6.1 Expanding the loss function

In order to include this additional effect of leaning on the cost of financial crises, the loss function from Svensson's analysis must be expanded. Svensson examines the intertemporal welfare loss from leaning, where the welfare loss is measured as the quadratic deviation in unemployment from its equilibrium. He evaluates the effect of leaning by finding the derivative of the expected loss with regards to the policy rate. Given the assumption that the expected non-crisis unemployment gap is zero, he finds the following expression for the effect of leaning,

$$\frac{dE_1 L_t}{di_1} = 2(p_t \Delta u)\frac{dE_1 u_t^n}{di_1} + [(\Delta u)^2]\frac{dp_t}{di_1}$$

The first term in the expression above is the marginal cost, while the second term is the marginal benefit of leaning, at time t. The sum of the cost and benefit gives the net marginal cost of leaning.

If one also considers the effect the policy rate has on the cost of crisis through its effect on the credit growth, the derivative is expanded with an additional term (still given the assumption of a zero expected non-crisis unemployment gap),

$$\frac{dE_1 L_t}{di_1} = 2(p_t \Delta u)\frac{dE_1 u_t^n}{di_1} + [(\Delta u)^2]\frac{dp_t}{di_1} + 2(p_t \Delta u)\frac{d\Delta u}{dG_t} * \frac{dG_t}{di}$$

The marginal cost is the same as before, while the marginal benefit has been expanded by an additional term. The marginal benefit now includes the effect of the policy rate on the crisis-induced increase in the unemployment rate, in addition to the previous effect on the crisis probability.

In order to estimate the net marginal cost of leaning, the terms $\frac{d\Delta u}{dG_t}$ and $\frac{dG_t}{di}$ have to be estimated. The latter term is simply the effect of the temporary policy rate increase on credit growth, which is given by the impulse response function from the VAR estimation. The first term, on the other hand, is a bit trickier to estimate considering the lack of studies, at least to the author's knowledge, on the direct effect of credit growth on the crisis-induced increase in unemployment. Nevertheless, the following section will give an attempt to estimate this relationship.

6.2 The effect of credit growth on the cost of crisis

The following table is taken from the paper by Jorda, Schularick & Taylor (2013), and it illustrates the effect of financial crises and excess credit growth on aggregated output. Aggregated output is measured as GDP per capita, and the estimates in the table give the percentage change in GPD per capita in year 1-5 after a crisis has erupted, compared to year zero. Comparing row 1 and 2, it can clearly be seen that the percentage drop in GDP per capita is larger for financial crises than for normal recessions in all the five following years after the crisis. The difference is also statistically significant. Looking at row 3 and 4, it can be seen that excess credit growth before the crisis has an additional effect on the drop in

output, and that the effect seem to be larger in the case of financial crises. This additional effect is not statistically different from zero in the case of normal recessions. Excess credit is measured as the percentage point deviation in credit growth from the sample mean in each of the two scenarios: financial crises and recessions.

Table 8: LP Conditional Paths — 7 Variable System, Normal v. Financial Bins and Excess Credit

Log real GDP per capita (relative to Year 0, ×100)	(1) Year 1	(2) Year 2	(3) Year 3	(4) Year 4	(5) Year 5
Normal recession (N)	-1.3^*	0.7	3.2^*	3.8^*	4.8^*
	(0.4)	(0.6)	(0.9)	(1.1)	(1.2)
Financial recession (F)	-2.8^*	-4.1^*	-3.6^*	-2.8	-1.4
	(0.6)	(1.0)	(1.4)	(1.8)	(1.9)
Excess credit × Normal recession ($N \times (\xi - \overline{\xi_N})$)	-0.3	-0.7^*	-0.8^+	-0.9^+	-0.7
	(0.2)	(0.3)	(0.4)	(0.5)	(0.6)
Excess credit × Financial recession ($F \times (\xi - \overline{\xi_F})$)	-0.4^+	-1.0^*	-0.4	-1.3^+	-0.9
	(0.2)	(0.4)	(0.5)	(0.7)	(0.7)
F-test Equality of coefficients, Normal=Financial (p)	0.01	0.00	0.00	0.00	0.00
F-test Equality of coefficients, interaction terms (p)	0.57	0.47	0.49	0.62	0.82
Observations, Normal	92	92	92	92	92
Observations, Financial	29	29	29	29	29
Observations	121	121	121	121	121

By summarizing the estimates from row 2, we find the accumulated effect on real output of a financial crisis. Summarizing give an estimate of -14.7, which means that the total cost of financial crises is a 14.7 % reduction in real output, compared to the level of real output before the crisis erupted. Summarizing the estimates in row 4 give an estimate of -4, meaning that for every unit of excess credit growth, real output is reduced by 4 % during the five years after a crisis[12].

We now have an estimate on what financial crises cost in terms of real output, but what we need to know is the cost in terms of unemployment. This can be achieved through the use of Okun's law, which states an inverse relationship between movements in output and movements in unemployment,

$$\Delta u_t = -\alpha \Delta y_t$$

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[12] An important caveat with the estimation in this chapter is the difference in the definition of credit growth. Jorda, Schularick & Taylor (2013) have constructed their excess credit growth variable as the percentage point change in the ratio of bank loans to GDP from the sample mean, in the expansion period (from trough to peak). While my credit growth variable is constructed as the percentage point deviation in quarterly growth of real loans, from the average growth rate in the sample. Obviously, the two credit measures above are not equal, and it is not quite clear how they relate to each other, and how good a substitution the latter is for the first.

The use of the word "law" might be somewhat of a misnomer as Okun's law is really more of an empirical relationship, than a theoretical one. The implication is that the magnitude of the relationship coefficient does not only vary between countries, but it has also been found to vary over time within countries. Nevertheless, Okun's law is still a useful tool in estimating short-term trends between unemployment and output. A study by Sögner & Stiassny (2002) estimated Okun's law for 15 OECD countries. The estimated coefficient for Norway was -0.31, meaning that a 1-percentage point increase in output growth will be accompanied by a reduction in unemployment of 0.31 percentage points[13]. This estimate is largely in line with other estimates of Okun's coefficient for Norway (see Hutengs & Stadtmann 2014, and Moazzami & Dadgostar 2009).

Given this estimate on Okun's law, it can easily be found that on average financial crises lead to a total increase in unemployment of 4.56 percentage points. This largely corresponds with Svensson's assumption about a fixed 5-percentage point increase in unemployment. However, utilizing the results regrading credit growth, it can be shown that for each unit excess credit growth before the crisis, unemployment will increase by 1.24 percentage points. In other words, Svensson's assumption of a fixed 5-percentage point increase in unemployment will only be suitable if credit growth remains constant at a certain level. This will obviously not be the case if leaning has an impact on the credit growth.

The two terms $\frac{d\Delta u}{dG_t}$ and $\frac{dG_t}{di}$ have now been estimated. The latter term is found from the impulse response function for credit growth, following the monetary policy shock, while the first term has been estimated to be $\frac{d\Delta u}{dG_t} = 1.24$. It now remains to estimate the marginal cost and benefit of leaning for the 40 quarters following the temporary policy rate increase, while including the effect of leaning on the cost of crises.

6.3 Cost and benefit of leaning when the crisis cost is affected by leaning

The monetary policy shock will have the same effect on the non-crisis unemployment rate and on the credit growth as in the benchmark model, and hence the same effect on the crisis

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[13] The study did uncover that for most of the countries in their sample, the Okun coefficient has decreased over time. However, the decrease in the coefficient for Norway was relatively modest compared to the other countries: while the coefficient for Norway was around -0.3 in 1960, it had decreased to around -0.4 in 1999 (these estimates are found from visual analysis of the figures in the paper).

probabilities. The only difference from the benchmark model is that the marginal benefit of leaning has been expanded by the additional effect of the policy rate on the crisis cost, and that we no longer assume that the crisis-induced increase in unemployment (Δu) is constant.
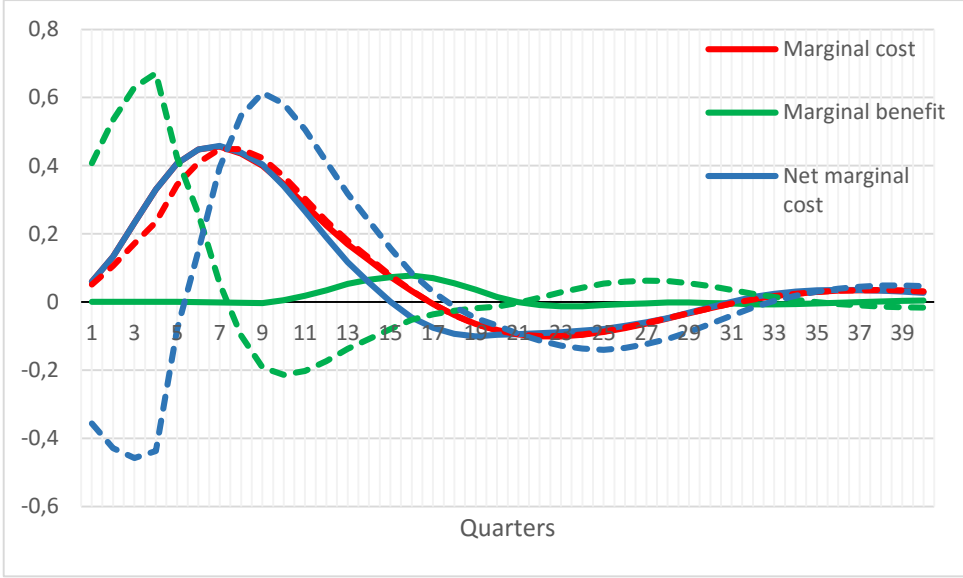

Figure 6.1: The effect on the marginal benefit, marginal cost and net marginal cost of expanding the loss function with the additional effect of the policy rate on the crisis cost (dotted lines), compared to the benchmark model (solid lines).

As seen from figure 6.1, the development in the marginal cost of leaning remains mostly the same as in the benchmark model. The small fluctuations in the MC-curve is a result of the marginal cost being dependent on Δu, which is not assumed constant anymore. Instead of Δu being constant at 5-percentage points, it is now a function of credit growth[14]. Furthermore, since leaning has a long term effect on credit growth (albeit a rather small effect), leaning will now also have a long term effect on Δu. This can be seen from the average of all the quarterly estimates on Δu in the 40 quarters following the monetary policy shock: the average of Δu has been reduced to 4.9 percentage points as a result of now being dependent on credit growth, compared to an average of 5 percentage points in the benchmark model.

The dynamic in the marginal benefit greatly differs from the dynamic found in the benchmark model. The monetary policy shock has a positive effect on the marginal benefit on impact. However, the marginal benefit turns negative in quarters 9-22, and then stays above zero for most of the remaining quarters. The reason behind this new dynamic is the fact that the marginal benefit is now a function of credit growth, and thus the marginal benefit largely

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[14] However, it is assumed that baseline is 5 percentage points. This implies that in the event of no excess credit growth before a crisis, the crisis-induced increase in unemployment is 5 percentage points. This baseline can be changed to 4.56 percentage points in order to correspond to the estimate found previously, but this does not change the results in any significant way.

follows the same dynamic as credit growth: the policy rate increase causes credit growth to fall on impact, followed by an increase above its baseline, and then to converge back to its baseline. In the benchmark model, the marginal benefit was positive in quarters 11-21. In the new model, the marginal benefit is now negative in these quarters, caused by the credit growth being above its baseline in these quarters. While the development in the marginal benefit previously was determined by changes in the crisis probability, the development in the marginal benefit is now largely determined by changes in the credit growth.

The main effect on the net marginal cost is a decrease in quarters 1-7, and an increase in quarters 8-21. These changes are caused by the new dynamic in the marginal benefit. The result of expanding the loss function in order to include the additional effect of leaning on the crisis cost is a large drop in the accumulated net marginal cost. This reduction is mainly caused by the large increase in the accumulated marginal benefit of leaning, compared to the benchmark model, while the accumulated marginal cost remains approximately the same. Even though the benefit of leaning is much larger in this expanded model, the accumulated net marginal cost is still positive, meaning that leaning is still not justified[15].

6.4 The additional effect of leaning when credit growth is high/low

One might wonder how the conclusions found in the section above is affected by a higher and lower credit growth. The short answer would be not very much. The figures below compare the model with the additional effect of leaning on crisis cost, and the same model but where the credit growth is adjusted to correspond to what was labelled "high" and "low" credit growth in the previous chapter[16].

In the case of high credit growth, there is a relatively large increase in the marginal benefit of leaning, as seen from figure 6.2. In fact, the accumulated marginal benefit over the 40 quarters increase by a third, compared to the model with "normal" credit growth. This increase in the benefit of leaning is mostly caused by the higher crisis probability; the intuition is that the benefit of reducing the crisis cost will be higher when the probability of experiencing a crisis is higher. However, the higher crisis probability will also increase the accumulated marginal cost of leaning, which is now 1.5 times higher than in the model with "normal" credit growth. Even though a higher credit growth causes a large increase in the benefit of leaning, it also

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[15] The accumulated net marginal cost is now 1.23, compared to 3.07 in the benchmark model.
[16] The "high" and "low" credit growths equal a quarterly credit growth of 1.6 % and 0.6 %, respectively.

causes an even larger increase in the cost. Thus, the conclusion that a higher credit growth will cause an increase in the accumulated net marginal cost holds for the case when the additional effect of leaning on the crisis cost is included[17].
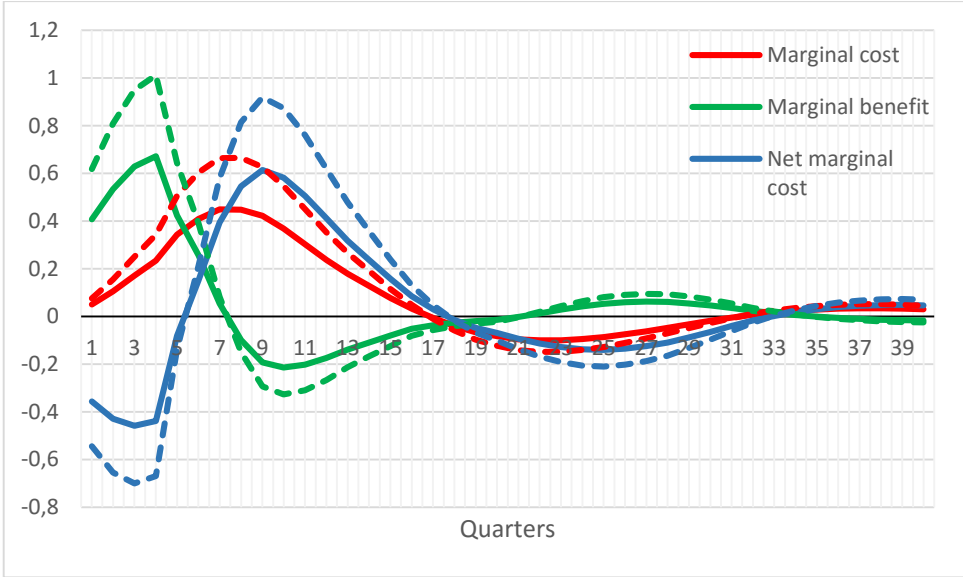

Figure 6.2: The effect of high credit growth in the model where the additional effect of the policy rate on the crisis cost is included (dotted lines), compared to the same model with average credit growth (solid lines).
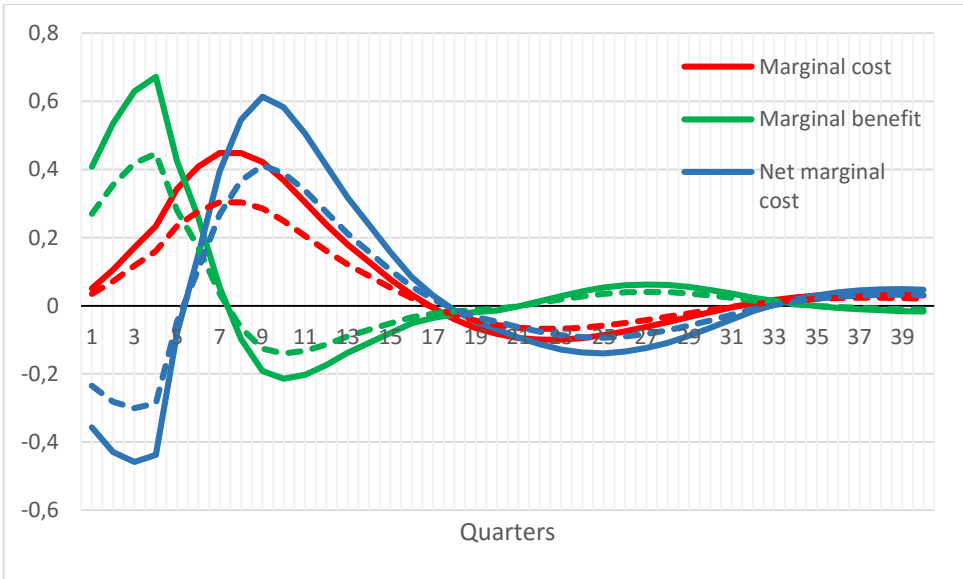

Figure 6.3: The effect of low credit growth in the model where the additional effect of the policy rate on the crisis cost is included (dotted lines), compared to the same model with average credit growth (solid lines).

As seen from figure 6.3, a lower credit growth than baseline will have the exact opposite effect on the cost and benefit of leaning: the lower crisis probability will decrease both the accumulated marginal benefit and the accumulated marginal cost. The intuition behind these

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[17] The accumulated net marginal cost is 1.78 in the case with "high" credit growth.

effects are again simple. It is less beneficial to take actions against future financial turmoil when the probability of encountering said turmoil is relatively lower. Furthermore, the relatively lower crisis probability also implies that it is less likely that the economy will encounter financial turmoil in the quarters when the non-crisis unemployment rate is raised, thus it is also less costly to pursue leaning. Even though both the benefit and the cost of leaning decreases in the case of lower credit growth, the latter effect dominates the first. This causes a reduction in the accumulated net marginal cost, compared to the case with "normal" credit growth. However, the accumulated net marginal cost is still found to be positive[18].

It has been found that the conclusion from the previous chapter that leaning is less justified in the case of higher credit growth holds, even when the additional effect of leaning on the crisis cost is considered. This result is not surprisingly considering that the only variables affected by an increased baseline credit growth is the actual crisis probability level and the derivative of the crisis probability with regards to the policy rate. While the marginal cost is a function of this first variable, the marginal benefit is a function of the latter. Increased credit growth will increase both of these variables, but the numeric increase in the actual level will always be larger than the numeric increase in the derivative, thus the increase in the marginal cost will always dominate the increase in the marginal benefit. This result remains unchanged by the inclusion of the additional effect of leaning on the crisis cost, given the assumption about a linear relationship between the policy rate and the credit growth in the VAR model[19].

6.5 Conclusion

It has been shown that the assumption of a fixed crisis-induced increase in unemployment by 5 percentage points is only suitable when there is no build-up of excess credit before the crisis. The literature on financial crises has, on the other hand, found that financial crises are often preceded by large spikes in credit growth. Furthermore, it has been found that financial crises that is preceded by excess credit growth in general cost more than financial crises with normal credit growth. The implication of these findings is that leaning has an additional benefit by reducing the credit growth: not only will it reduce the crisis probability, but it will

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[18] The accumulated net marginal cost is 0.86 in the case with "low" credit growth.

[19] If, on the other hand, the effect of the policy rate on credit growth was negative and *increasing* in the level of the credit growth, then it is possible that the inclusion of the additional effect of leaning on the crisis cost would affect this result. In this case, leaning will cause a larger reduction in the credit growth rate when initial credit growth is high. Furthermore, this larger reduction in credit growth will cause a larger reduction in the crisis cost, and thus increase the marginal benefit and decrease the marginal cost. It is not investigated in this thesis if such a non-linear relationship between the policy rate and credit growth is a reasonable assumption.

also reduce the crisis cost. Expanding the loss function to include this additional effect of leaning and assuming that the crisis cost is no longer constant, causes a relatively large increase in the marginal benefit of leaning. The marginal cost is, on the other hand, mostly unaffected by the adjustment of the loss function. However, given the estimates derived above on the effect of leaning on the crisis cost, the marginal cost is still larger than the marginal benefit. In other words, leaning is still not found to be justified when assuming a reasonable estimate on the additional effect of leaning on the crisis cost. Adjusting the analysis for high and low credit growth will not affect the conclusion. A higher credit growth will increase the marginal benefit of leaning, but it will also increase the marginal cost. The opposite is true in the case of low credit growth. The net marginal cost will be increase in the case with high credit growth, while it will decrease in the case with low credit growth, though it will still be positive.

6.6 Further remarks

It is important to point out that increasing (decreasing) the estimate for $\frac{d\Delta u}{dG_t}$ will not linearly increase (decrease) the marginal benefit of leaning. Increasing the coefficient on this relationship between the crisis-induced increase in unemployment and credit growth will only increase the marginal benefit up to a point[20]. Further increases above this point will decrease the marginal benefit, and thus increase the net marginal cost (the marginal cost of leaning is mostly unaffected by adjustments to this coefficient). Increasing $\frac{d\Delta u}{dG_t}$ has two effects on the marginal benefit of leaning: since credit growth falls below baseline on impact from the monetary policy shock, the marginal benefit will increase in the first couple of quarters. However, the marginal benefit will decrease in the following quarters when credit growth is pushed above its baseline.

The magnitude of these effects are both increasing in $\frac{d\Delta u}{dG_t}$, but after a certain threshold, the second, negative effect will dominate the first, positive effect. This is caused by the marginal benefit being a function of Δu which is no longer constant, but instead a function of credit

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[20] Increasing $\frac{d\Delta u}{dG_t}$ above 1.24, which is the estimate found in this chapter, will increase the marginal benefit and decrease the net marginal cost. This will generally be the case until $\frac{d\Delta u}{dG_t}$ reaches 1.87. Increasing the estimate above this point will decrease the marginal benefit, and increase the net marginal cost. At this local minimum point, the net marginal cost equals 0.998, thus leaning is still not justified.

growth. When credit growth is below baseline, Δu will be below 5 percentage points, and when credit growth is above baseline then Δu will be above 5 percentage points. When $\frac{d\Delta u}{dG_t}$ increases, the effect of credit growth on Δu will also increase, and hence Δu will exhibit larger deviations from its baseline. In other words, Δu will be smaller in the initial quarters after the monetary policy shock when credit growth is below its baseline, and larger in the following quarters when credit growth is above its baseline. Hence, the "weight" on the positive effect of credit growth on the crisis cost is decreasing, and the "weight" on the negative effect is increasing, when $\frac{d\Delta u}{dG_t}$ increases.

7 The benchmark model with Swedish data

Svensson's conclusion that leaning is not justified in terms of the cost outweighing the benefit has generally been upheld in this thesis where the analysis has been executed on Norwegian data and with different modifications. However, contrary to Svensson, I do find that leaning has a benefit by reducing the accumulated crisis probability in the following 40 quarters after the monetary policy shock; the reduction is just not large enough to counteract the cost incurred by leaning. The remaining question is if this difference between the findings in Svensson (2015) and the findings here is a result of a different dynamic of monetary policy shock in Norway and Sweden, or if it is caused by different estimation techniques, namely VAR estimations as opposed to DSGE estimation. In order to clarify this confusion, I have in this chapter re-done Svensson's analysis on Swedish data, but where the effects of the monetary policy shock are found from VAR estimation. The VAR model used is the same model that I used previously in the thesis, and readers interested in more information about the dataset and estimation is referred to appendix 2. Even though it has been established earlier that it would be erroneous to assume a fixed crisis cost, the additional effect of leaning on the crisis cost has been left out from the analysis below. This has been done intentionally, since the purpose of this chapter is not to investigate whether leaning is justified in Sweden or not, but instead to clarify the effect of the use of Swedish/Norwegian data and VAR/DSGE estimation on the outcome of the analysis. This is also the reason why the potential problems with non-stationarity in the VAR model have not been given more attention (see appendix 2).

7.1 Monetary policy shock in Sweden

The figures below illustrate the effect of a monetary policy shock given by VAR estimation on Norwegian and Swedish data. From figure 7.1, we can see that the same shock of a 1-percentage point increase in the policy rate on impact leads to a rather different dynamic in the Swedish policy rate, compared to the Norwegian policy rate, in the following 40 quarters. The Swedish policy rate falls back to its initial level after the shock, but instead of falling below baseline, as we would expect, it rises above it again. The Swedish policy rate has not converged back to its baseline within the 10-year horizon. This rather odd dynamic in the policy rate is most likely a result of the non-stationarity in the times series for the policy rate (see appendix 2).
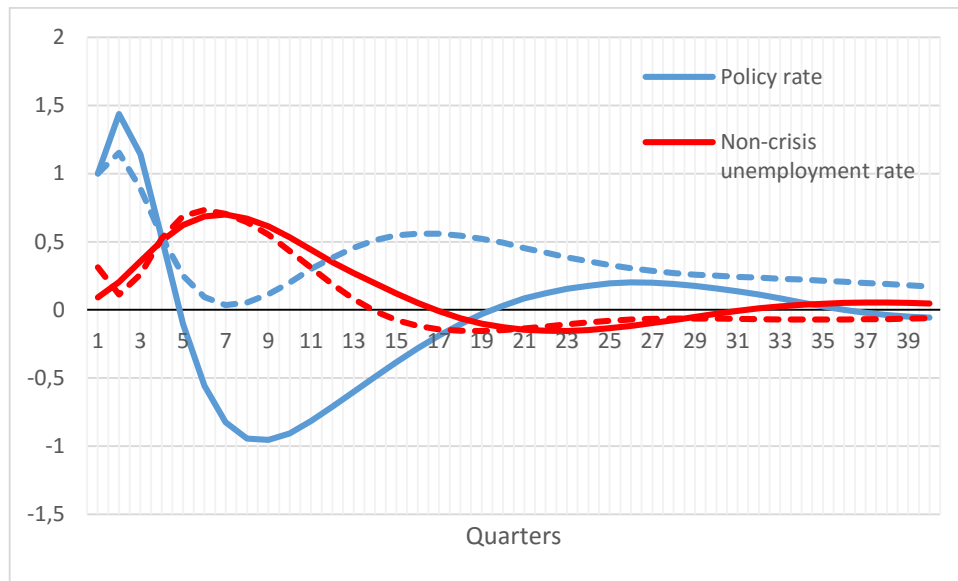
Figure 7.1: The effect of the monetary policy shock on the policy rate and the non-crisis unemployment rate in Norway (solid lines) and Sweden (dotted lines).

Nevertheless, the Swedish non-crisis unemployment rate closely follows the same dynamic as the Norwegian non-crisis unemployment rate: it has a maximum deviation of 0.7 percentage points above baseline, before gradually converging back to its initial level within the time horizon.

As seen from figure 7.2, the dynamic in credit growth in the Swedish model also differs from the Norwegian model: credit growth falls more sharply on impact, and instead of converging back to baseline, it yet again grows above it and stays there throughout the remaining quarters[21]. This is most likely yet another result of the non-stationarity in the time series. Even though Swedish credit growth falls more on impact, the accumulated effect on credit growth within the time horizon is twice as large in Norway as it is in Sweden[22]. As a result of the strange dynamic in credit growth, the crisis probabilities for Sweden also exhibit a dynamic different from the previously found dynamic in the crisis probabilities for Norway. However, because of the non-linear nature of the logit model, the accumulated effect on the crisis probabilities by the monetary policy shock is larger in Sweden than in Norway, even though accumulated credit growth is reduced by more in Norway[23].

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[21] Baseline annual credit growth is assumed to be the average annual credit growth in the sample, which was 6.42 % in the Swedish dataset. This gives a baseline probability of crisis start and baseline probability of crisis of 0.92 % and 6.42 %, respectively.

[22] By the end of the 40 quarters, credit growth has been reduced by 3.06 percentage points in Norway, and only 1.2 percentage points in Sweden.

[23] The accumulated probability of crisis in any given quarter is reduced by 1.65 percentage points in Norway, while it is reduced by 2.5 percentage points in Sweden.
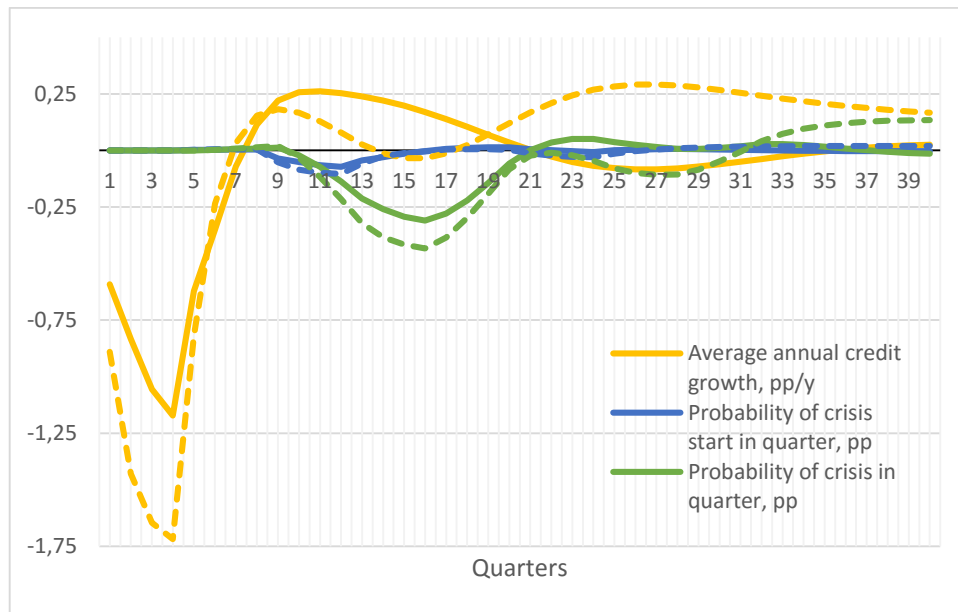
Figure 7.2: The effect of the monetary policy shock on average annual credit growth and the crisis probabilities in Norway (solid lines) and Sweden (dotted lines).

7.2 Cost and benefit of leaning in Sweden

As before, the marginal cost is a function of the crisis probability, the crisis-induced increase in unemployment, and the effect of leaning on the non-crisis unemployment rate. Since baseline crisis probability and the development in non-crisis unemployment caused by the monetary policy shock are approximately the same in Sweden and Norway, the MC-curve for Sweden largely corresponds to the MC-curve for Norway.
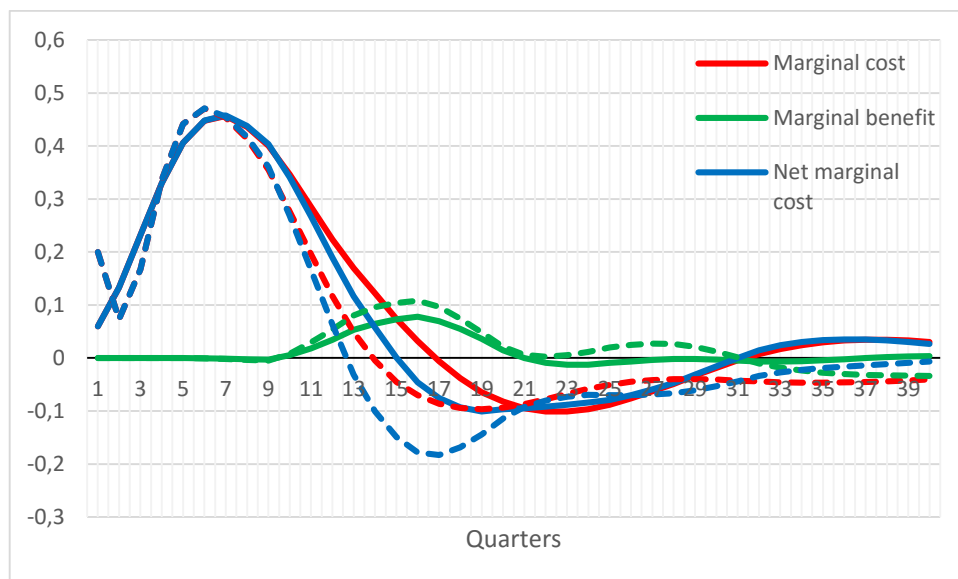
Figure 7.3: The marginal cost, marginal benefit and net marginal cost of leaning in Norway (solid lines) and Sweden (dotted lines).

However, because of a larger reduction in the accumulated crisis probability and a somewhat smaller increase in the non-crisis unemployment rate, the accumulated marginal cost of leaning is smaller in Sweden than in Norway[24]. Furthermore, the larger reduction in the crisis probability in Sweden means that the marginal benefit of leaning is larger there than in Norway[25]. Nevertheless, the difference in the marginal benefits is small, and the marginal benefit is still small in both countries, compared to the marginal cost. The decreased cost and the increased benefit of leaning means that leaning is actually a *more* justified policy to pursue in Sweden than in Norway, but it is still not justified in terms of incurring a larger benefit than cost within Svensson's framework[26].

7.3 Conclusion

The findings in this chapter seem to indicate that the reason why Svensson finds no benefit of leaning in his analysis is not caused by the use of Swedish data, but instead a result of the DSGE estimation. My findings above indicate that the ability of the policy rate in creating long-term deviations in credit growth (albeit only small ones) is not only an artefact of Norwegian monetary policy, but is also the case in Sweden. This means that the fact that Svensson could not find any long-term benefit of leaning must be caused by the use of DSGE estimation, or perhaps more accurately, Svensson's use of DSGE estimation. It seems that Svensson has used a DSGE model where it has been assumed that monetary policy can have no long-term effect on real credit levels, which makes it no surprise that he ends up with the results that he does. With such a restriction in place, any decrease in credit level from baseline caused by a monetary policy shock must be followed by a rise back to baseline. This further implies that in order for the credit level to converge back to its steady state, credit growth must first fall below baseline, only to be followed by an exact increase above baseline. If such a restriction has been used, it would imply that Svensson's analysis is bordering on circular reasoning: instead of the conclusion being a result of the premise, the premise (monetary policy has no long-term effect on credit growth) has become a result of the conclusion.

Svensson's conclusion can be summed up as:

"Leaning is not justified since it has only costs and no benefit, because monetary policy has no long-term effect on credit growth".

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[24] The sum of all the marginal cost is 2.07 in Sweden, compared to 3.48 in Norway.
[25] The sum of all the marginal benefit is 0.62 in Sweden, compared to 0.41 in Norway.
[26] The sum of the net marginal cost is 1.44 in Sweden, compared to 3.07 in Norway.

In the above statement, the conclusion is derived on basis of the premise, which seems reasonable. However, in Svensson's analysis, the marginal benefit of leaning is a function of the effect of the policy rate on credit growth, $MB = f(\frac{dG_t}{di_t})$. Given this fact, the above statement actually says the following:

"Leaning is not justified because monetary policy has no long-term effect on credit growth, because monetary policy has no long-term effect on credit growth".

The chance that leaning might have benefits, and therefore might be justified, has already been excluded in the premise for the analysis. With that said, it is important to point out that this does not mean that DSGE models cannot be used to estimate the cost and benefit of leaning[27].

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[27] As was pointed out to me by Ørjan Robstad in Norges Bank, DSGE models can be used to estimate leaning by for instance changing the behaviour of the central to respond to changes in credit growth caused by shocks. The analysis would then investigate how well the bank manages to stabilize credit growth after shocks, and how much this cost in terms of unemployment. Baseline in this instance would be a central bank not concerned about credit growth, only unemployment.

8 Summary and conclusion

There is an ongoing debate among economists and policy makers on whether central banks should include financial stability concerns in their policy rules, or if they should continue with traditional inflation targeting regimes. The background for this debate is an increased occurrence of financial crises and the accompanying cost in the post WWII-era (Schularick & Taylor 2012), and the realization that price stability is not sufficient to ensure financial stability (Woodford 2012). The policy of "leaning" is one way to implement financial stability concerns in monetary policy. Leaning is usually understood as an ad hoc policy, where in times of financial instability the central bank responds by temporarily increasing the policy rate by more than what is justified by inflation and output stability concerns. Whether leaning is a suitable policy to pursue is dependent on how large the benefit is compared to the cost.

The main task of this thesis was to calibrate Svensson's (2015) cost benefit analysis of leaning for Norway, using VAR estimation, as opposed to the DSGE estimation used by Svensson. Svensson evaluates leaning through its effect on credit growth, which has been singled out as an important source of financial instability (Schularick & Taylor 2012). Svensson examined the marginal benefit and cost of a temporary 1-percentage point increase in the policy rate over the following 40 quarters. This temporary increase in the policy rate has a benefit in the medium-run through its effect on credit growth, and thus crisis probability, while it has a cost through increased unemployment in the short-run.

While Svensson found no benefit of leaning, only cost, I find that leaning can have a beneficial effect on the crisis probability by lowering credit growth. Nonetheless, I too find that the cost generally outweighs the benefit of leaning, both in my benchmark model and in the different adjustments of the model. However, I have uncovered that there are two assumptions made in Svensson's analysis that are erroneous and bias the analysis in favour of the cost. The underlying assumption in the DSGE models used by Svensson to estimate the monetary policy shock is that the policy rate can have no long-term effect on real credit levels. Such an assumption causes circular reasoning since the conclusion that leaning do not have any benefits, has become the premise for the analysis. By not imposing this restriction in the VAR model used to estimate the monetary policy shock in Norway, I have found that leaning do have a benefit, albeit a small one compared to the cost.

The second erroneous assumption is the fixed 5-percentage point increase in unemployment, caused by financial crises. Not only is there a relationship between the crisis probability and

credit growth, but new research has also established a relationship between credit growth and the crisis cost (see Jorda, Schularick & Taylor 2013). This implies that if leaning is successful in decreasing credit growth, then it will not only reduce crisis probability, but if a crisis were to occur, it would be less costly. Including this additional effect of leaning greatly increases the benefit. However, the benefit is still outweighed by the cost, thus leaning was still not found to be justified.

The fact that leaning is generally not found to be justified in terms of having larger benefit than cost, is caused by the inclusion of the additional cost of leaning in Svensson's analysis. A temporary increase in the policy rate will incur a cost by increasing the non-crisis unemployment rate in the short-run, also known as the "regular" cost. However, increasing the unemployment rate has an additional cost by forcing the economy to start out at a higher unemployment level if a crisis were to occur, thus increasing the damage inflicted by the crisis on the economy. Increased credit growth, and thus increased crisis probability, will generally increase the benefit of leaning. However, it will also increase the cost since it is now more likely that a crisis will strike and cause higher unemployment. This causes a dilemma in Svensson's analysis; leaning is most expensive when it is arguably most needed.

8.1 Further considerations

Even though this thesis has tried to test and adjust for some of the assumptions made in Svensson's cost-benefit analysis, it still suffers from being only a partial analysis of leaning, meaning that it only uses credit growth as the financial variable that links the policy rate to financial stability. There are a great number of different financial variables that leaning works through, and leaning will generally have a different effect on those variables in both sign and magnitude. Although credit growth has been singled out as an important source of financial instability, there are many other equally important variables, and credit growth is perhaps among those variable that is least affected by the policy rate. It has for instance been found that financial crises are often preceded by rapid house price growth, and furthermore; house price growth is very responsive to changes in the policy rate. Any future analysis of leaning should try to include more of the relevant variables that leaning works through, in order to give a more complete assessment of the benefit and cost of pursuing such a policy.

Another important consideration for future analyses of leaning is the theory of secular stagnation. If the proponents of secular stagnation are right, then it means that there is an

increasing trade-off between stabilizing output and inflation on the one hand, and financial risk on the other, in monetary policy. In developed countries, output and inflation have seemingly become less responsive to the policy rate, and as the policy rate is nearing its zero lower bound, central banks have been forced to pursue unconventional monetary policies. This development has led some economists to question the role of monetary policy in encouraging economic growth. As Lawrence Summers (2016) put it "Let's get fiscal", meaning that increased fiscal policy is needed in order to achieve inflation and output stability.

While the effect of the policy rate on output and inflation has become less certain, what is certain is that such low policy rates can be detrimental to the financial soundness of an economy. The theory of secular stagnation suggests that the effect of monetary policy shocks on unemployment and financial stability is not the same when the policy rate is at "normal" levels, as when it is close to the zero lower bound as today. As a consequence, future studies on leaning should evaluate how this seemingly non-linearity in the policy rate affects the trade-off between the cost and the benefit of leaning. For instance, if output has become less responsive to the policy rate relative to credit growth, then the cost of leaning would decrease, which would improve the case for leaning within Svensson's framework for analysis.

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Appendix 1: The VAR model with Norwegian data

The VAR model used in this analysis is largely based on a VAR model developed by Robstad (2014). The reduced form VAR model has the following form,

$$y_t = C_0 + A_1 y_{t-1} + \cdots + A_l y_{t-l} + u_t \tag{1}$$

where y_t is a vector of endogenous variables, C_0 is a constant, l is the number of lags, and u_t is a vector of error terms at time t. It is further assumed that,

$$E(u_t) = 0, E(u_t u_t') = \Sigma_u, E(u_t u_s') = 0, \forall\, t \neq s$$

where Σ_u is the variance-covariance matrix.

Robstad (2014) includes 6 macroeconomic variables in his VAR in order to identify how monetary policy shocks impact the economy. I use the same set of variables, except that I include the unemployment rate instead of the output gap. The variables included are:

- Nominal interest rate: 3-months NIBOR

- Unemployment rate: Official unemployment rate from NAV, seasonally adjusted.

- Price level: Consumer price index adjusted for tax changes and excluding energy products (CPI-ATE), seasonally adjusted.

- Real exchange rate: Trade-weighted nominal exchange rate index (I-44) for 44 trading partners adjusted for relative prices in Norway and abroad, seasonally adjusted.

- Real credit level: Household credit deflated with the consumer price index (CPI-ATE), seasonally adjusted.

- Real house prices: Nominal house prices deflated with the consumer price index (CPI-ATE), seasonally adjusted.

As in Robstad (2014), I will use a sample that starts in 1994Q1. The reason why is that in order for a VAR analysis to identify monetary policy shocks, it is crucial that there are no structural breaks in the monetary policy followed by the central bank within the time period. By the mid-90's the deregulation of credit markets was mostly completed, and although inflation targeting was not officially implemented until 2001; the disinflation process was also completed by the mid-90's (Robstad 2014). The figure below clearly illustrates the effect on inflation of the structural break in monetary policy. By limiting our sample to the period starting with 1994Q1, we stand a better chance at identifying true structural shocks instead of regime shifts.
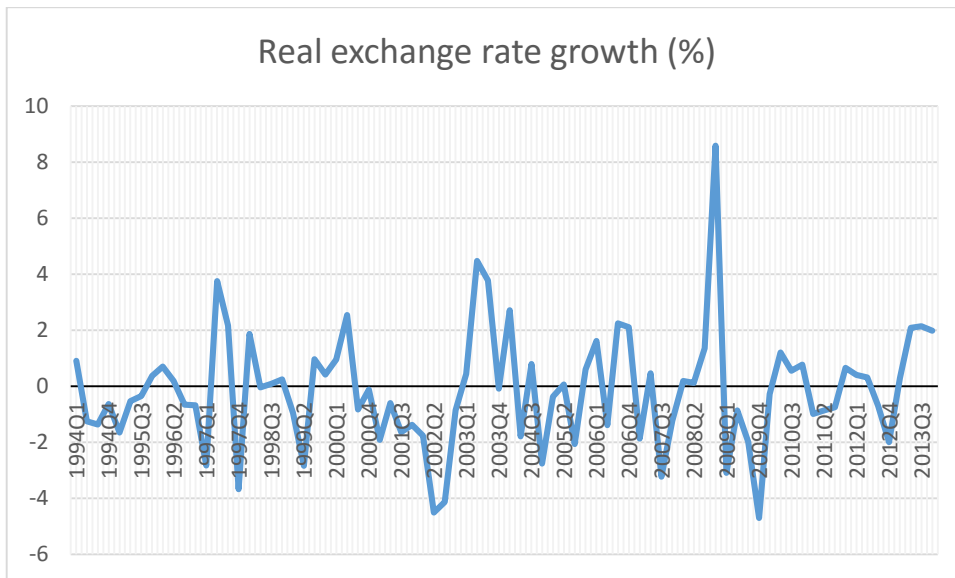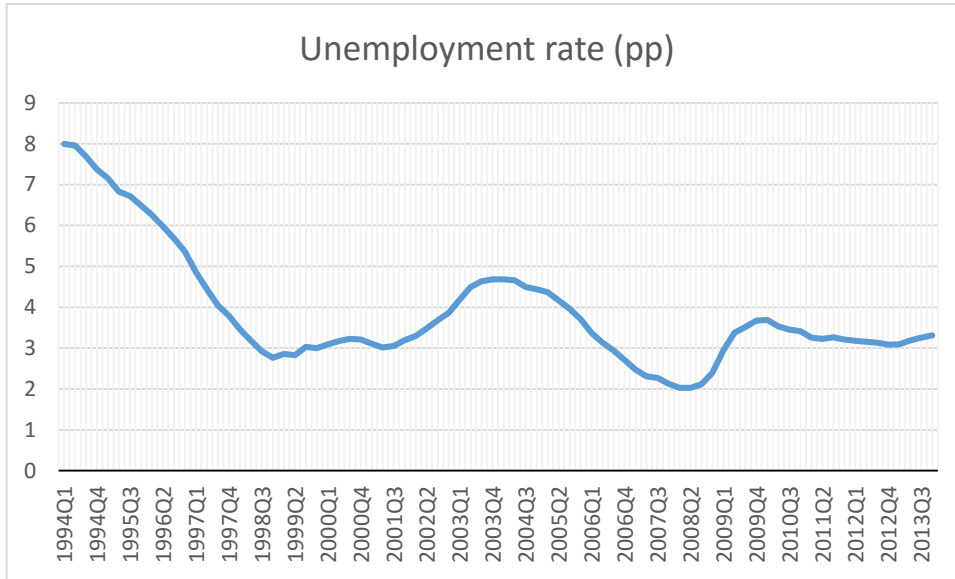
Inflation (CPI-ATE), 4-quarter growth (%)
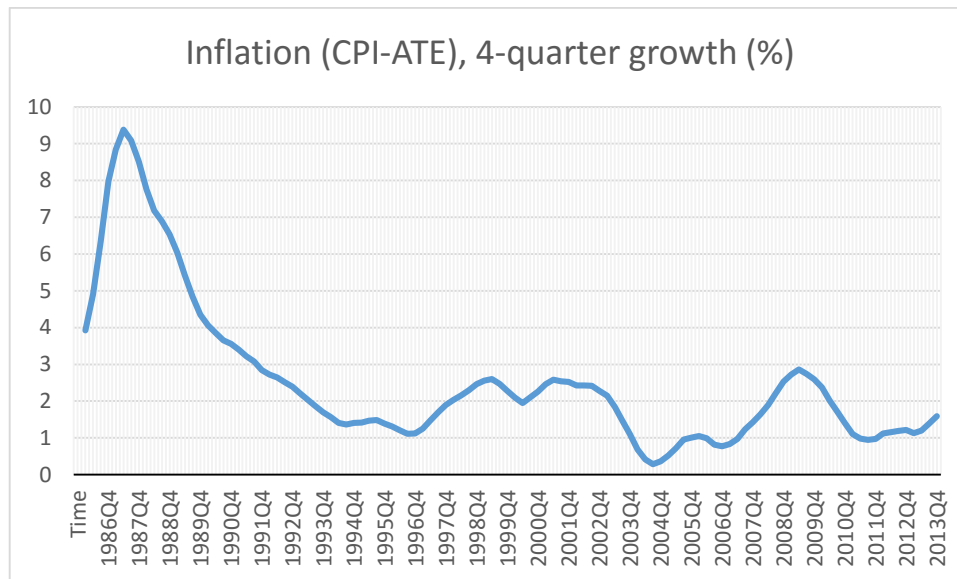
Another crucial underlaying assumption for VAR analysis, is the absence of non-stationarity in all the variables. An augmented Dickey-Fuller test on the price level, real exchange rate, real credit level, and real housing prices, fails to reject the null hypothesis about the presence of a unit root. As a solution these variables are converted to log differences, and they can now be interpreted as growth variables. The policy rate and the unemployment rate are on ther other hand kept as level variables[28]. The ADF-test now shows that all variables are stationary, except for the credit growth variable. As a solution to the non-stationarity in credit growth, I use the credit variable constructed by Robstad (2014), who uses a band-pass filter in order to remove all low-frequency movements. The band-pass filter removes all growth cycles that excedes 8 years in the real credit variable, and the variable is then transformed to log differences. As seen from the figure below, the credit variable now exhibit stationarity (this can also be seen from a formal ADF-test).

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[28] While the ADF-test clearly rejects the null hypothesis of a unit root in the unemployment variable, even at a 1% significance level, the null hypothesis cannot clearly be rejected in the case of the policy rate. However, the policy rate is kept on level form since this gives the most appropriate interpretation in the further analysis. Furthermore, the ADF-test is known for its low statistical power, meaning that it has difficulty in clearly separating a true unit-root process from a near unit-root process.

70

Real credit growth, band-pass filter (%)
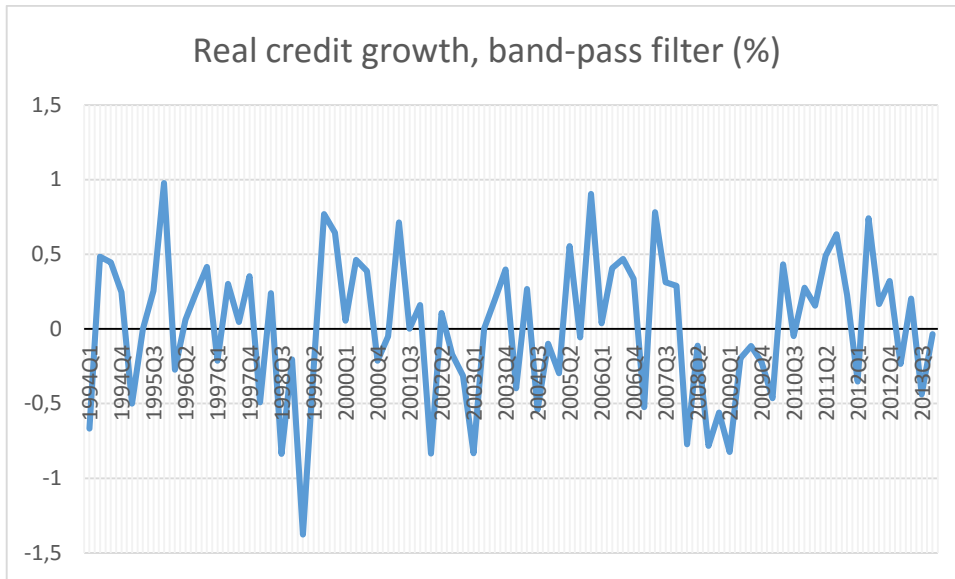
The rest of the variables in the analysis are illustrated below for the sample 1994Q1 to 2013Q4. The figures clearly show that most of the variables seem to be stationary, with the excpetion of the policy rate which seems to be boarderline non-stationary.

Policy rate (pp)

Unemployment rate (pp)

Real exchange rate growth (%)

Inflation (CPI-ATE), 4-quarter growth (%)

Real house price growth (%)
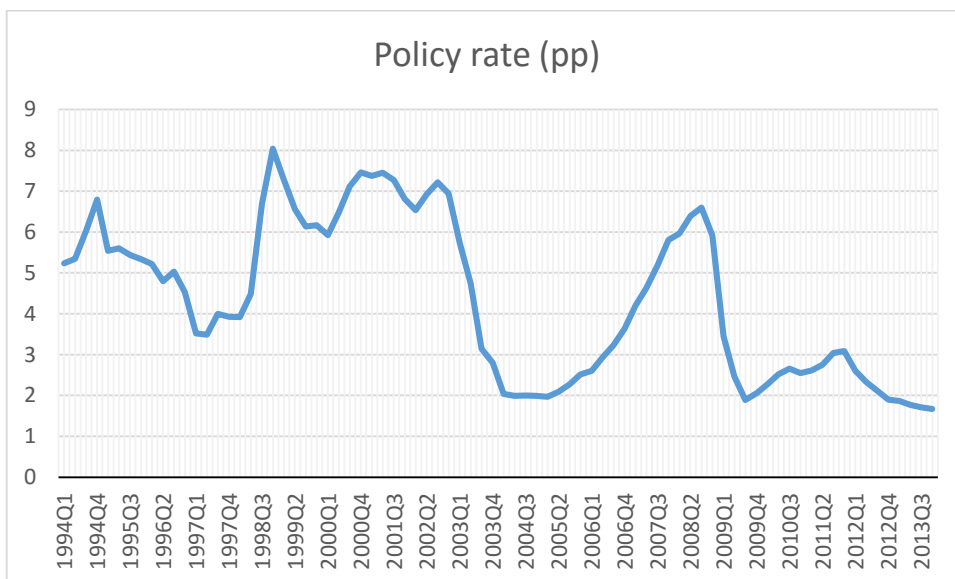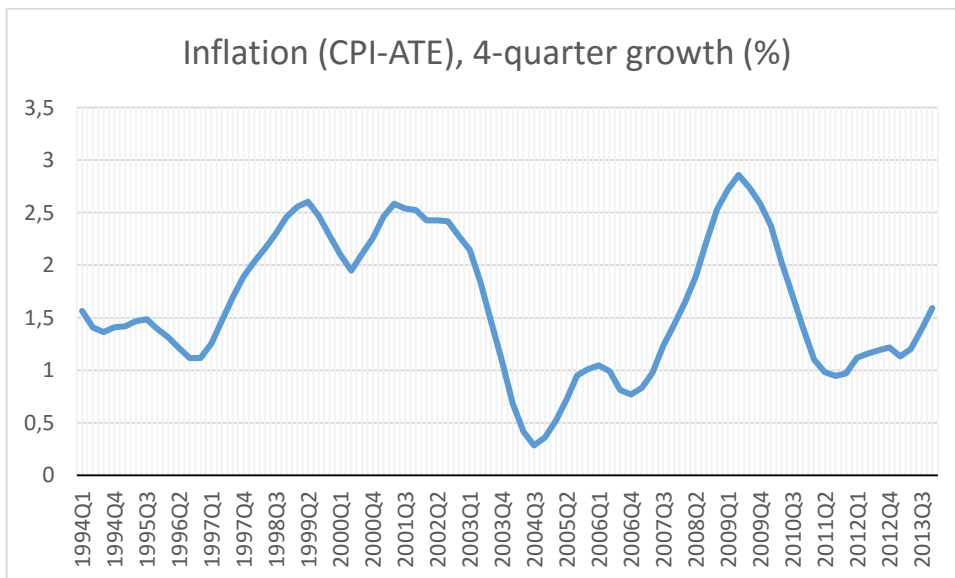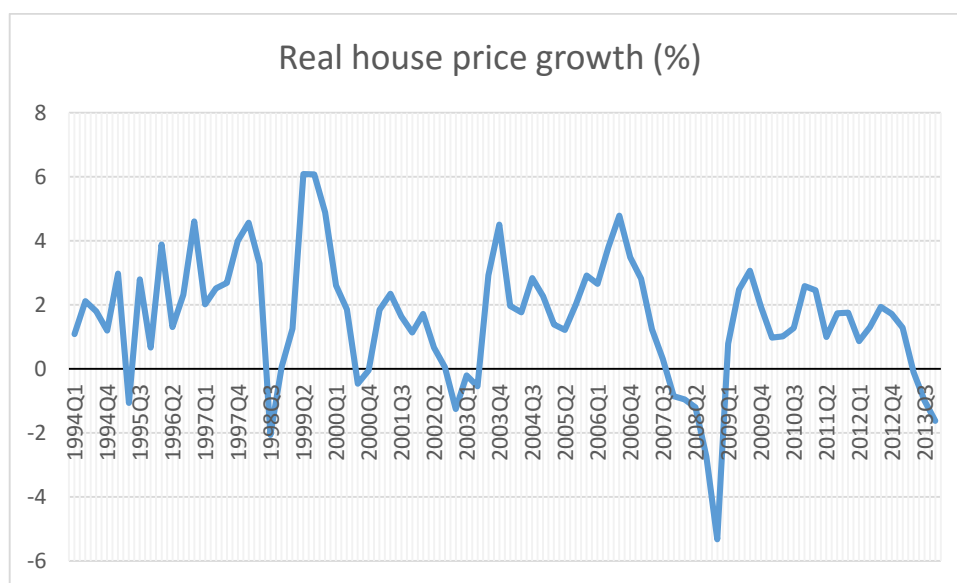
The Schwarts and Hannan-Quinn information critierion find two lags to be optimal, while the Aikake information criterion find two lags to be second best. I therefore chose two lags in my benchmark VAR model.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	1394.188	NA	3.38e-24	-37.01834	-36.83294	-36.94431
1	1785.010	708.6913	2.63e-28	-46.48027	-45.18247	-45.96207
2	1896.258	183.9296	3.60e-29*	-48.48687	-46.07669*	-47.52451*
3	1916.687	30.50800	5.72e-29	-48.07166	-44.54908	-46.66513
4	1965.157	64.62623	4.49e-29	-48.40418	-43.76921	-46.55349
5	2013.079	56.22905*	3.82e-29	-48.72212*	-42.97475	-46.42726

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The structural VAR and impulse responses

Because the error terms in the reduced form VAR in (1) also reflects the contemporanous effects from the endogenous feedback from shocks in the economy, they cannot be interpreted as structural shocks. In order to identify the effect of a monetary policy shock, we need a VAR model that represents the underlying structures of the economy, a so-called structural VAR model. It is typically cast in the following form:

$$B_0 y_t = C_0 + B_1 y_{t-1} + \cdots + B_l y_{t-l} + \varepsilon_t \qquad (2)$$

where B_0 is a matrix with the contemporaneous effects between the variables, and where $B_0^{-1} B_l = A_l$ in the reduced form VAR. The vector ε_t contains the error terms. We further assume,

$$E(\varepsilon_t) = 0, E(\varepsilon_t \varepsilon_t') = I, E(\varepsilon_t \varepsilon_s') = 0, \forall\, t \neq s$$

where I is the identity matrix. The error terms in (2) are purged for all the contemporaneous effects, there are therefore no covariance between the error terms, and they can thus be interpreted as structural shocks. A Breusch-Godfrey test shows that two lags are sufficient in order to eliminate all autocorrelation between the error terms[29].

Lags	LM-Stat	Prob
1	29.71661	0.7607
2	33.85415	0.5710

Probs from chi-square with 36 df.

There are a number of ways to identify the contemporaneous effects in a structural VAR model. In line with Robstad (2014), the structural VAR is in this case identified by using sign restrictions, which entails putting restrictions on the sign of the contemporaneous effects of the impulse responses stemming from the structural shocks. It has been assumed that a monetary policy shock has on impact a positive effect on unemployment and exchange rate growth, while it has a negative effect on inflation, credit growth and house price growth. Readers interested in a closer discussion of these restrictions, are referred to Robstad (2014).

The structural VAR model has been estimated in Matlab with the help of an algorithm developed by Andrew Binning (see Binning 2013). The algorithm searches until it finds a B_0 −matrix that satisfies the restrictions. This is repeated a 1000 times, and the impulse response functions are computed as the median from these draws. A 67 % confidence band is computed as well. An advantage with sign restrictions as opposed to for instance Choleski identification, is that they allow for simultaneity between the policy rate, credit and housing prices. The downside with sign restrictions is that it does not necessarily identify monetary policy shocks as there can be several specifications of the B_0 matrix that satisfy the
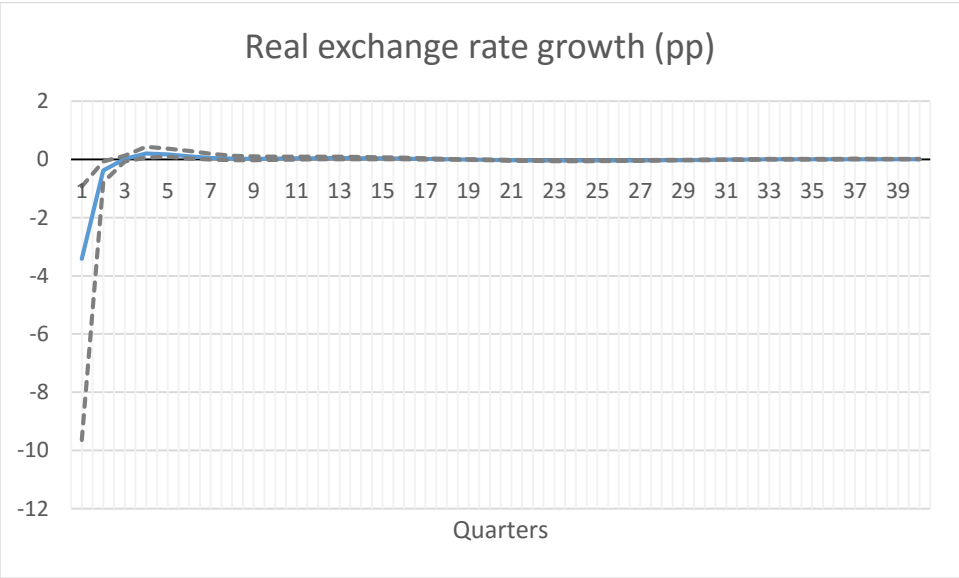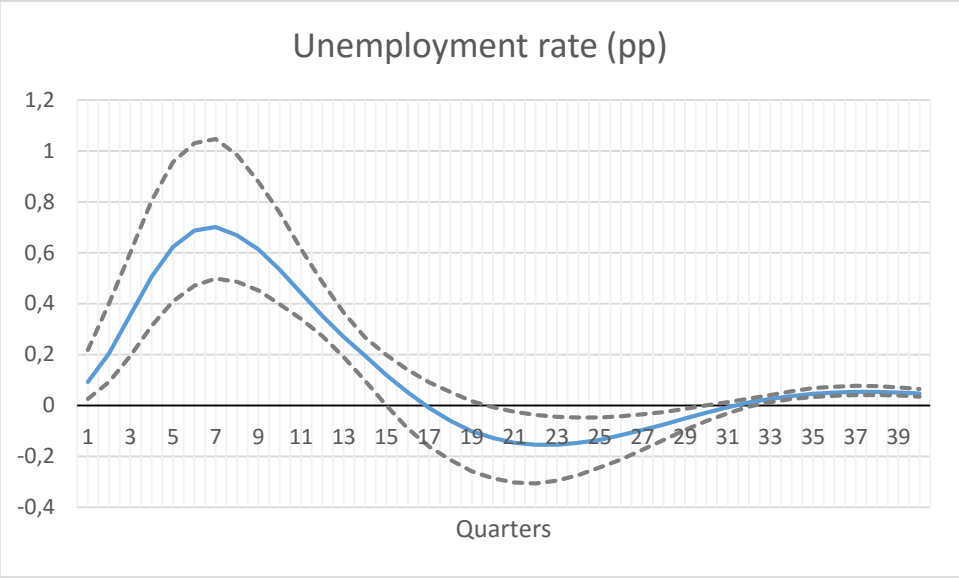
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[29] It is common in structural VAR models to include up to four lags in order to be certain that all autocorrelation is controlled for. In addition to the formal Breusch-Godfrey test, I have also expanded the model with four lags and investigated how this affected the impulse response functions. The conclusion was that the impulse responses remained largely the same in the 4-lag model, as in the 2-lag model; hence, autocorrelation seems not to be a problem in the model with only two lags.
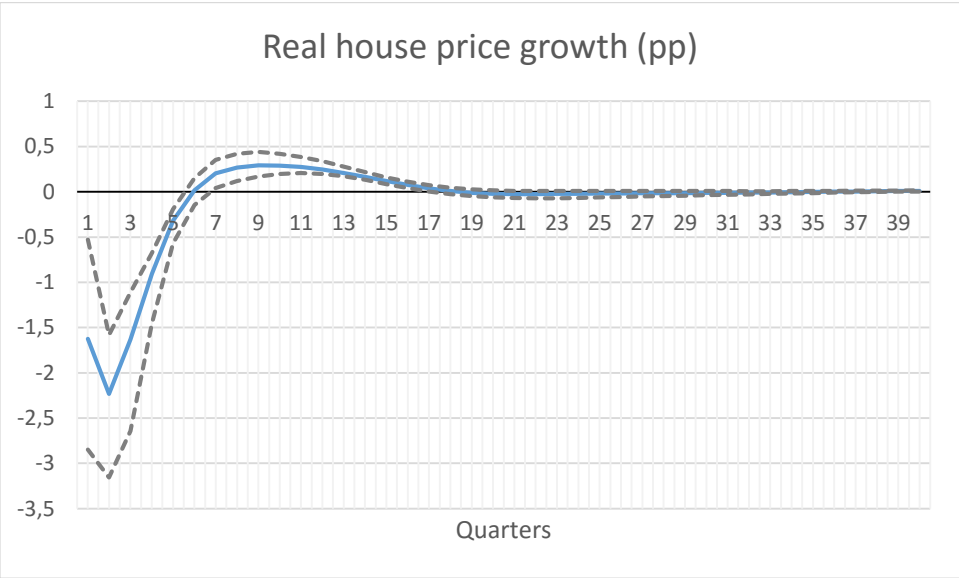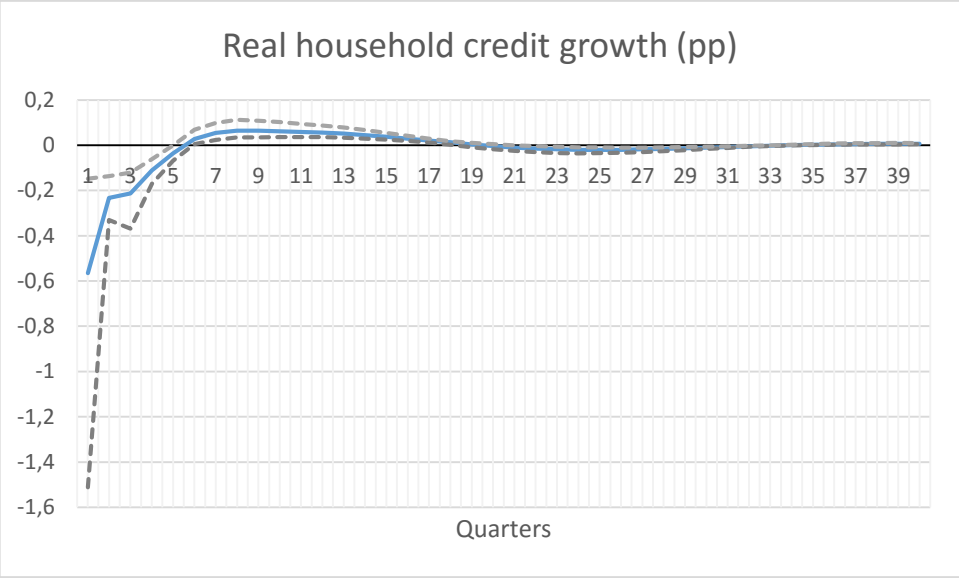
restrictions. This implies that sign restriction is relatively weak, and several restrictions must be imposed in order to separate monetary policy shocks from other types of shocks.

What I need the VAR model for in this thesis, is to quantify the effects of an exogenous increase in the interest rate on unemployment and household credit, as this is central to do the cost-benefit analysis of leaning. We get that from the estimated VAR model using impulse-response functions for a monetary policy shock.

The estimated median impulse response functions (solid lines) and the corresponding 67 % confidence band (dotted lines) for all the variables are illustrated below. The monetary policy shock has been normalized to yield a one-percentage point increase in the policy rate at impact, and the impulse responses are illustrated for the following 40 quarters after the shock. The impulse responses give the percentage point deviations in the variables, caused by the monetary policy shock.

Unemployment rate (pp)

Real exchange rate growth (pp)

4-quarter inflation (pp)

76

Real household credit growth (pp)

Real house price growth (pp)
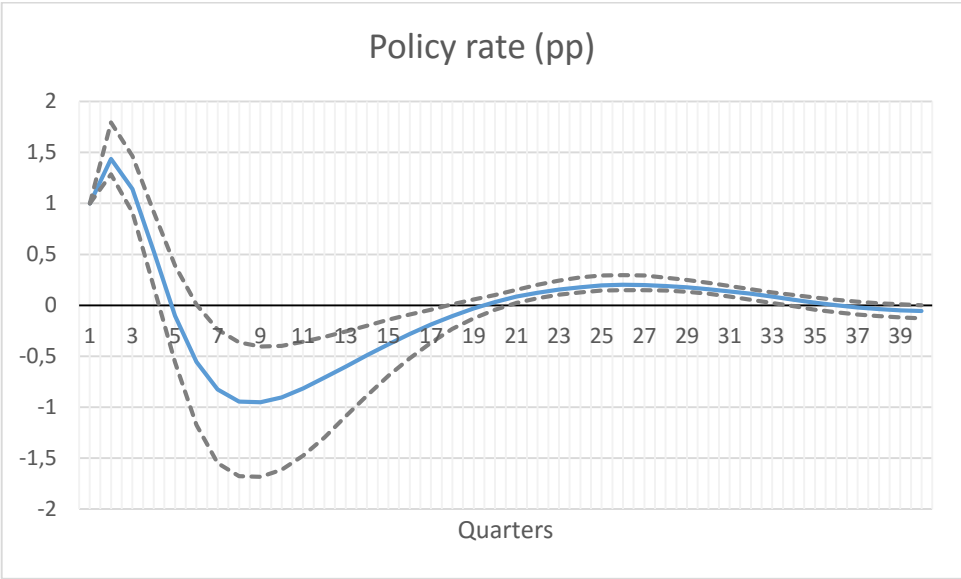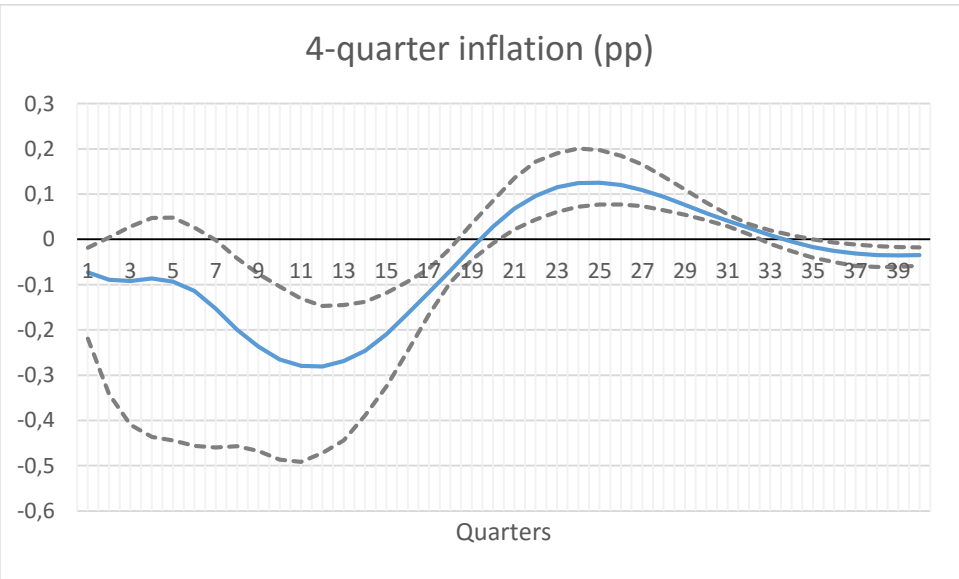
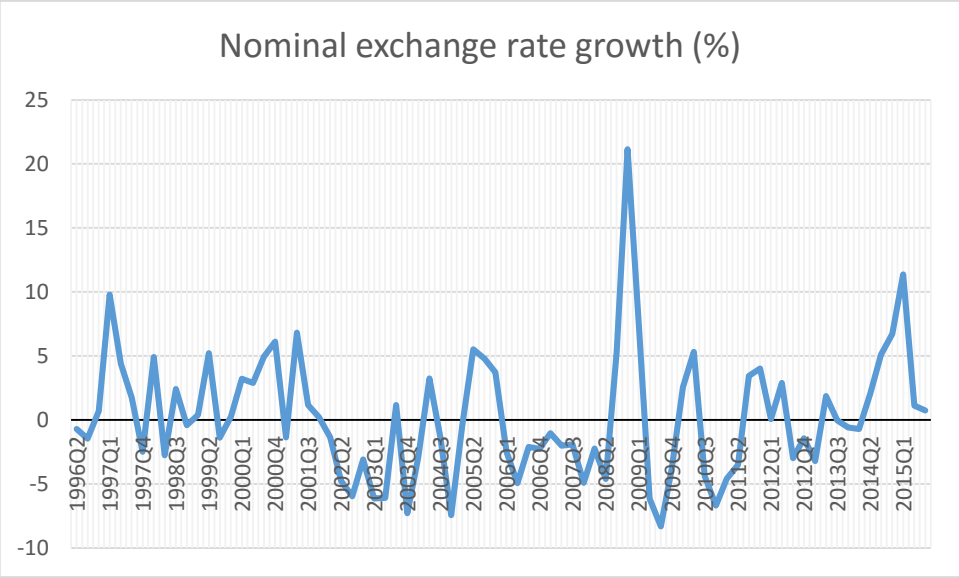# Appendix 2: The VAR model with Swedish data

The variables included in the model are the same as before. The Swedish dataset is constructed by the use of OECD's statistics bank, and because of different availability of Norwegian and Swedish data, both the sample period and the variables in the Swedish dataset are constructed slightly different. The dataset consists of observations from 1996Q2 to 2015Q3, and the variables are defined in the following way:

- Nominal interest rate: 3-month rates.
- Unemployment rate: Swedish official unemployment rate, seasonally adjusted.
- Price level: Consumer price index, excluding food and energy products, seasonally adjusted.
- Exchange rate: Nominal exchange rate, the price of one dollar in terms of SEK.
- Real credit level: Nominal household credit deflated with the consumer price index.
- Real house prices: Nominal house prices deflated with the consumer price index, seasonally adjusted.

An augmented Dickey-Fuller-test fails to reject the hypothesis about a unit root in all the series, except in unemployment. As a consequence of this non-stationarity, the price level, exchange rate, credit level and house prices level are all converted to log difference, and thus they can be interpreted as growth variables. Even though there seems to be a unit root present in the policy rate, the variable is kept in its original level form. The policy rate in the VAR model with Norwegian data also exhibited some signs of non-stationarity, though it was decided that this might be the result of the low statistical power of the ADF-test. However, it seems that the problem with non-stationarity is more severe in this model with Swedish data. One way to handle this non-stationarity is to convert the policy rate to log difference, but that would create an inappropriate interpretation of the monetary policy shock, compared to the VAR model with Norwegian data. Bjørnland & Jacobsen (2010) utilizes time dummies in order to control for structural breaks and deviations from the Taylor rule in Swedish monetary policy. Inclusion of such time dummies would solve the problem with non-stationarity, while maintaining the policy rate in its level form. However, considering the time and effort required, I have decided to not expand the model with times dummies. Even though this can cause some troubles with the stability of the system, the VAR model seems to be stable even though the policy rate exhibits non-stationarity (a formal test shows that all the unit roots are within the unit circle).

The figures below illustrate the variables included in the Swedish dataset for the sample period 1996Q2-2015Q3. From the figures, it is easy to see that all the variables exhibit stationarity, except the policy rate.
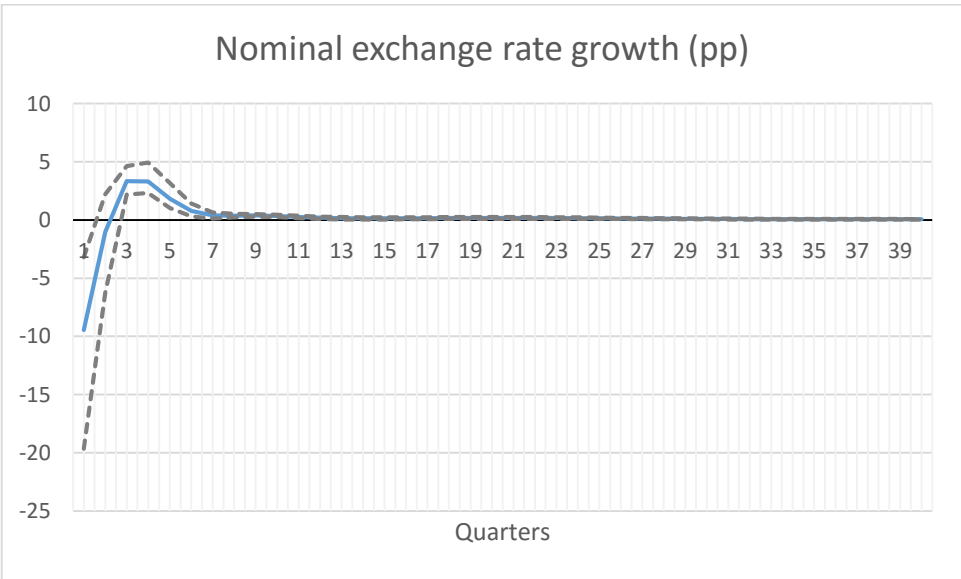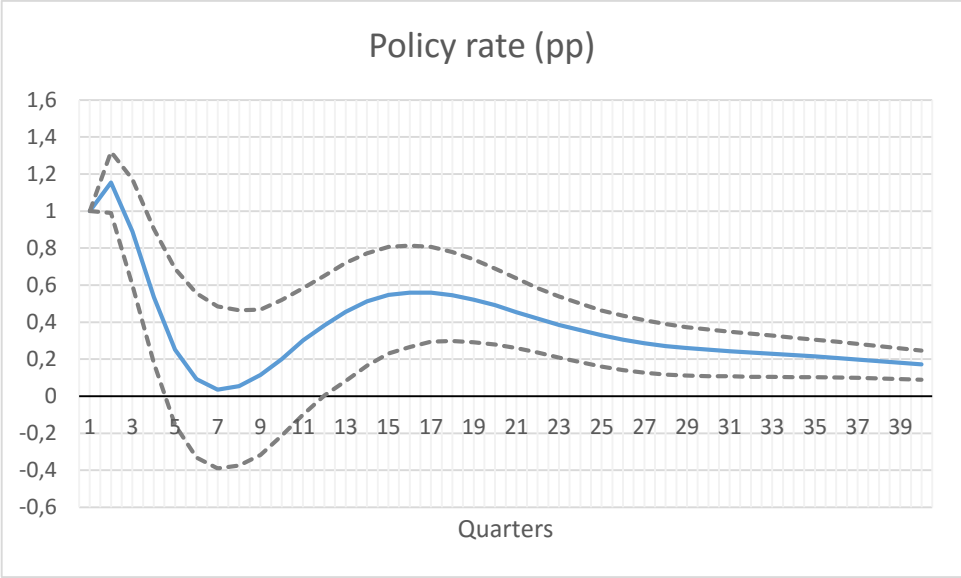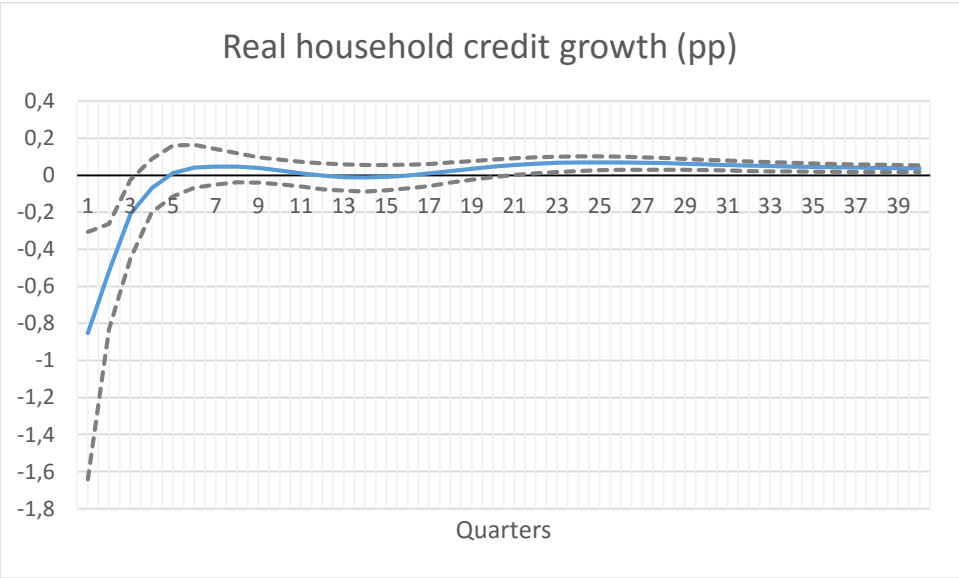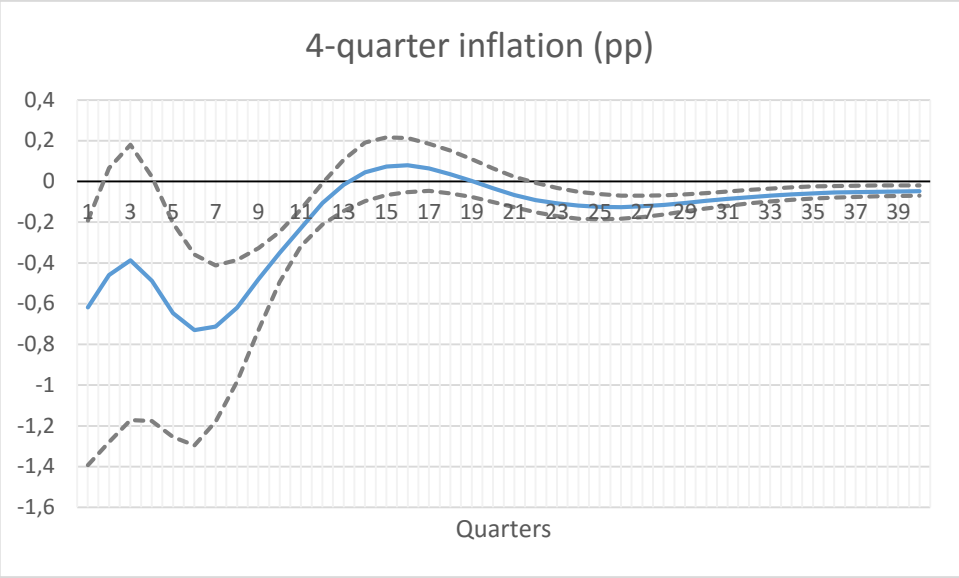

Policy rate (pp)

Unemployment rate (pp)

Nominal exchange rate growth (%)

Inflation, 4-quarter growth (%)

Real household credit growth (%)

Real house price growth (%)
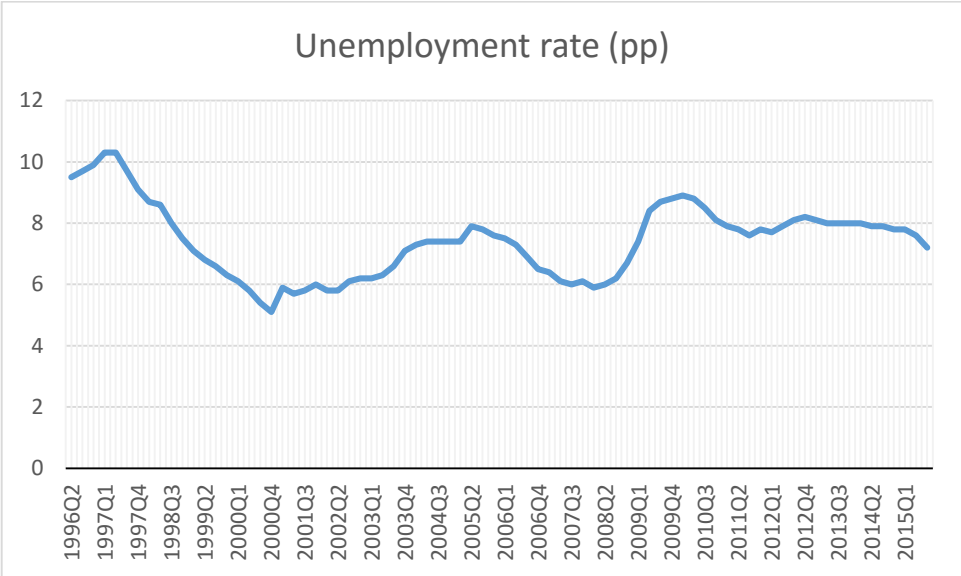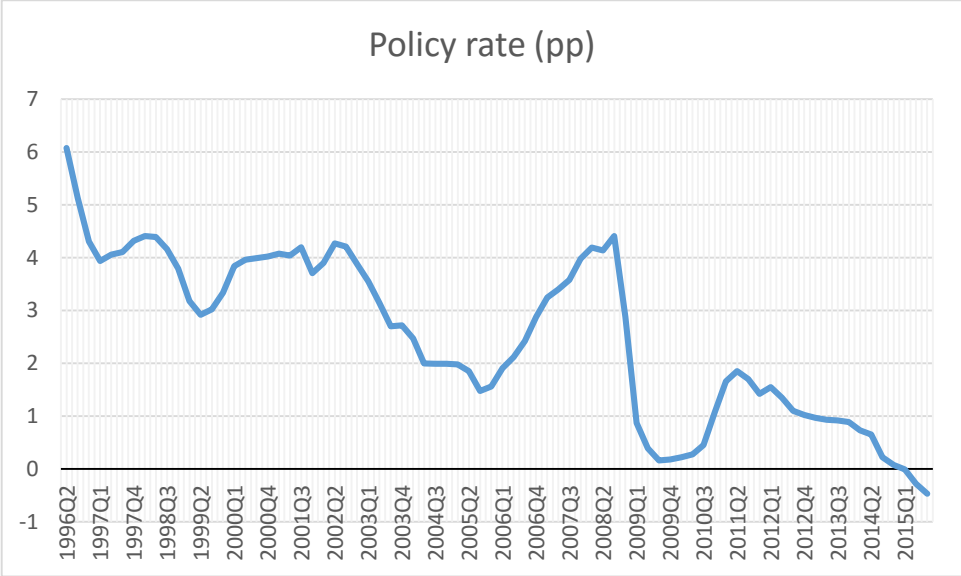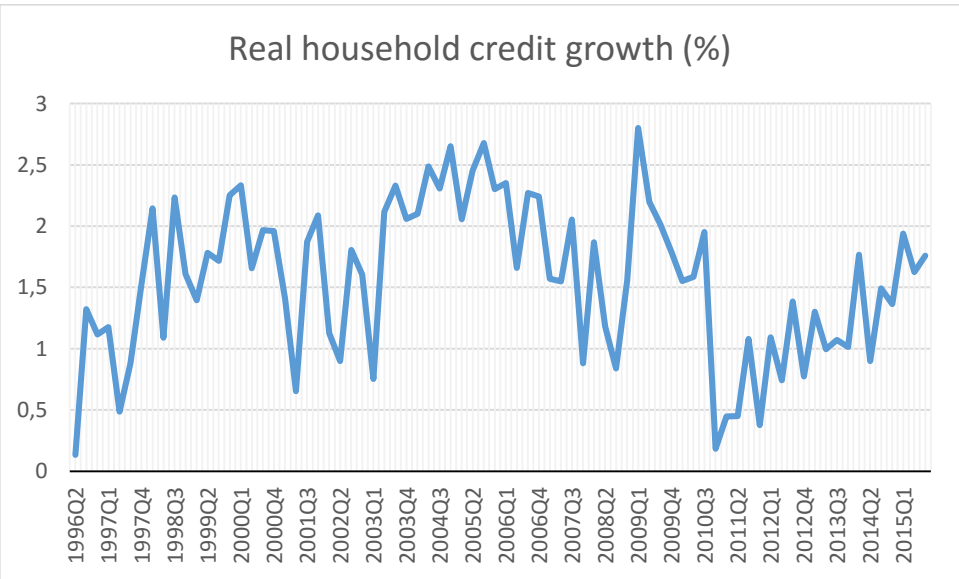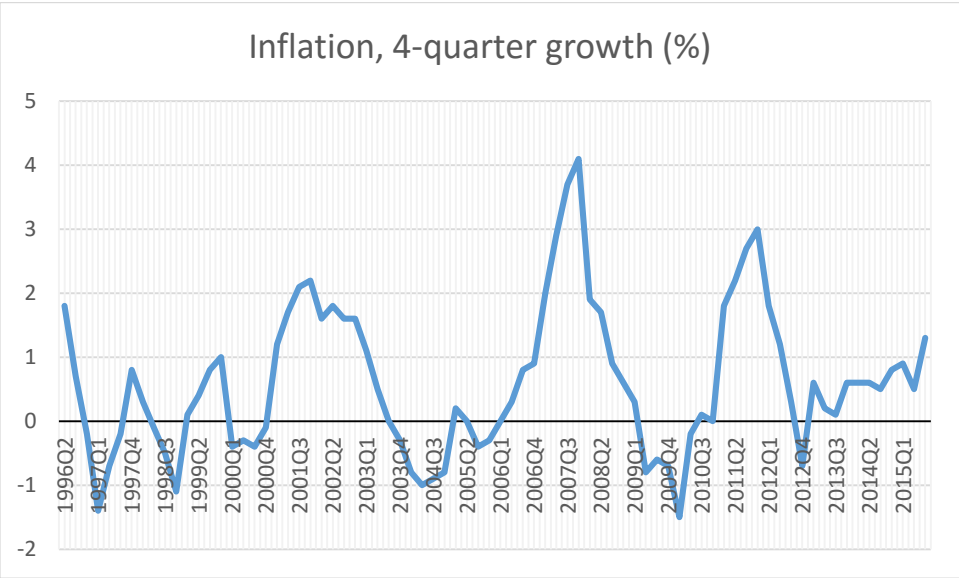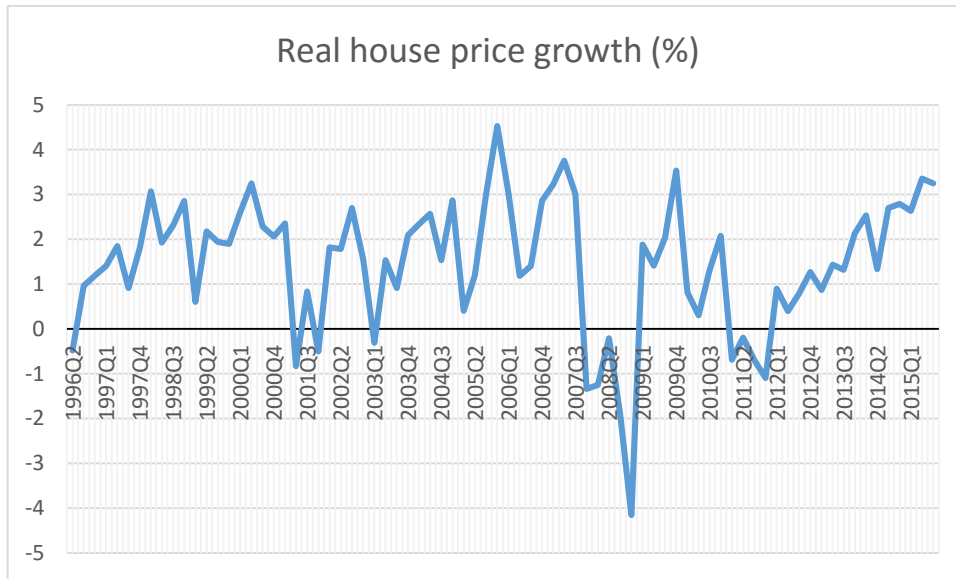
The lag length is still chosen to be two as this is found to be optimal. As in the model with Norwegian data, two lags is first best in the Schwarts and Hannan-Quinn information critierion, while second best in the Aikake information criterion. Furthermore, a Breusch-Godfrey test confirms that two lags are sufficient in order to eliminate all autocorrelation between the error terms in the structural VAR-model.

As before, sign restrictions are used in order to identify the monetary policy shock. The figures below illustrate the estimated median impulse response functions (solid lines) and the corresponding 67 % confidence band (dotted lines) for all the variables. The monetary policy shock has been normalized to a one-percentage point increase in the policy rate, and the impulse responses are illustrated for the following 40 quarters after the shock. The impulse responses give the percentage point deviations in the variables, caused by the monetary policy shock.

Policy rate (pp)

Quarters

Unemployment rate (pp)

Quarters

Nominal exchange rate growth (pp)

Quarters

83

4-quarter inflation (pp)

Real household credit growth (pp)

Appendix 3: Sensitivity and uncertainty in the benchmark model

Figures from the sensitivity analysis

Svensson test the robustness of his result in five different sensitivity analysis. I do the same on my benchmark model, and the effect on the marginal benefit, marginal cost and net marginal cost in the different scenarios, compared to the benchmark model, is illustrated below. The conclusion from the benchmark model holds in all cases; the accumulated net marginal cost is positive, thus leaning cannot said to be justified.
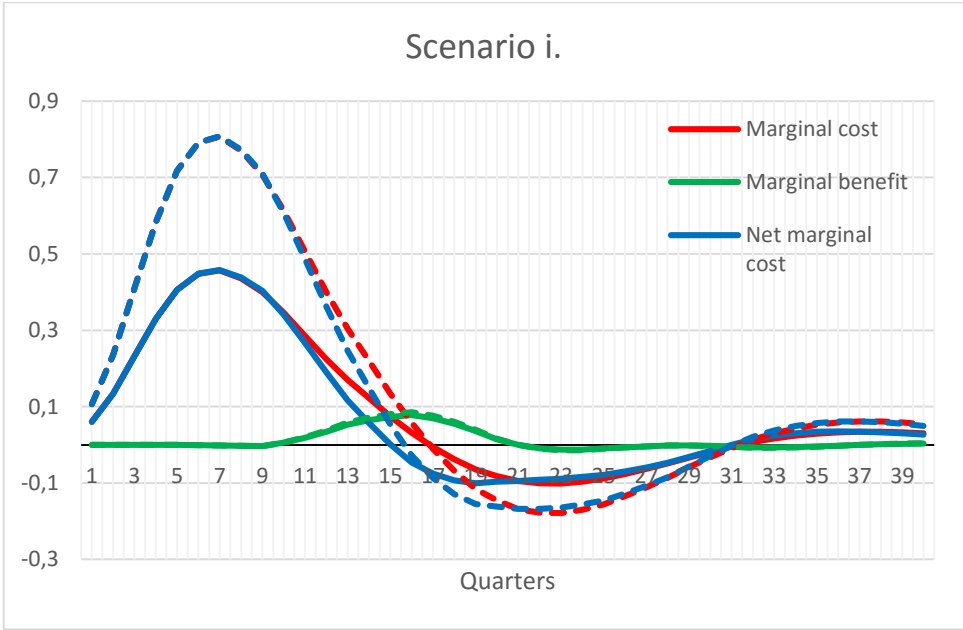
Figure 0.1: A positive non-crisis unemployment gap of 0.25 percentage points.
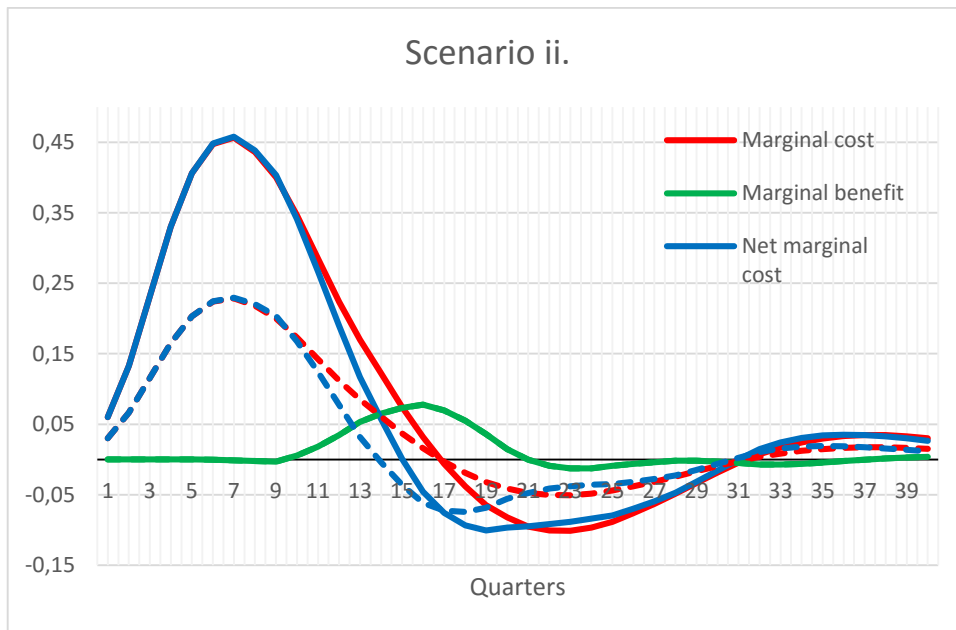
Figure 0.2: The effect of the policy rate increase on the non-crisis unemployment rate is halved.
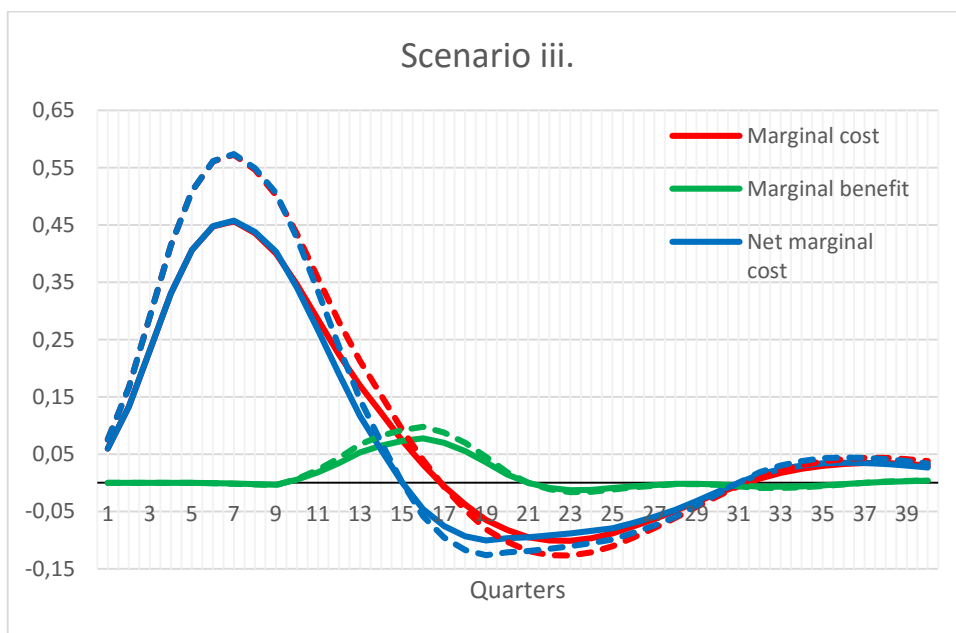

Figure 0.3: The annual probability of a crisis start in the absence of leaning is 1 percentage point higher.
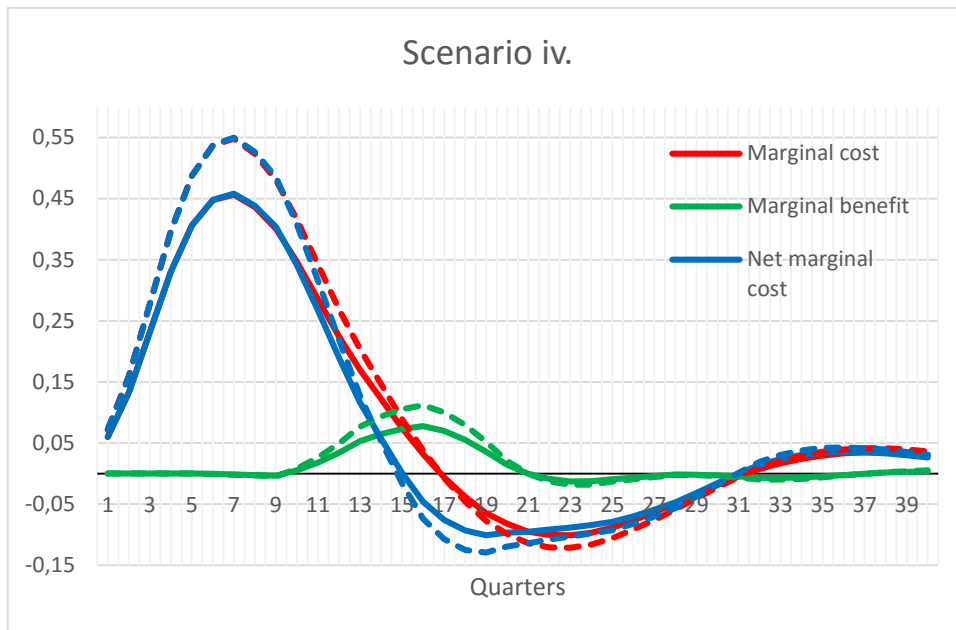
Figure 0.4: The cost of a crisis increases from 5 to 6 percentage points increase in the unemployment rate.
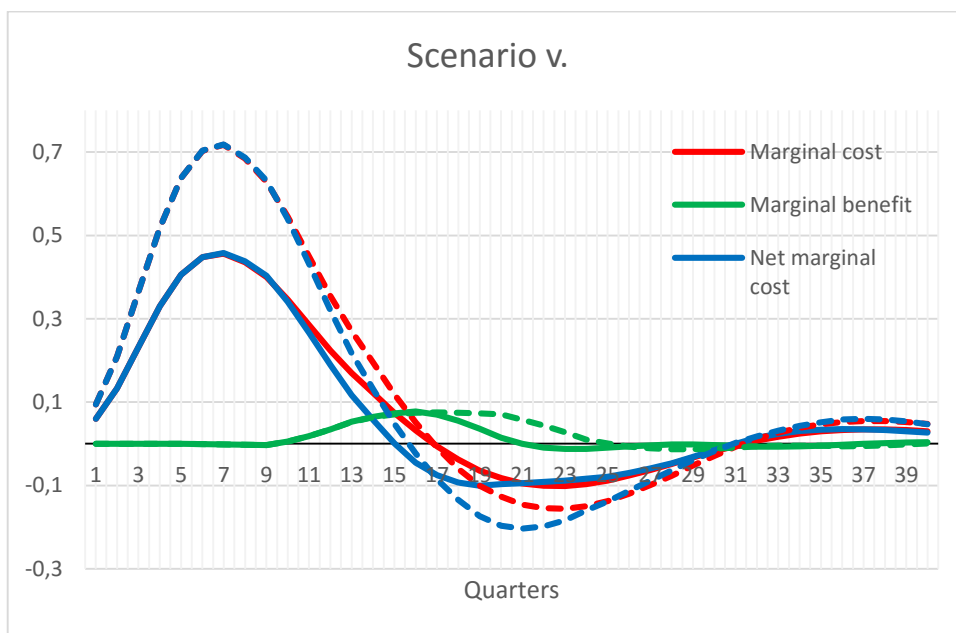

Figure 0.5: The duration of a crisis increases from 8 to 12 quarters.

Uncertainty in the estimates

The benchmark model developed in the thesis is based on the median estimates from the VAR model. However, as seen in appendix 1, the uncertainty in the estimates from the VAR model is quite large, and can potentially influence the results from the benchmark model. In this

section, I examine how the use of the upper and lower bounds in a 67% confidence band influence the results[30].

The figure below illustrates how the use of the upper bound in the 67% confidence interval affects the development in the policy rate and the non-crisis unemployment rate following the monetary policy shock. This will be referred to as the extreme scenario. The benchmark model is given by the solid lines, while the upper bound estimates are given by the dotted lines. In the extreme scenario, there is a sharper increase in the policy rate, and though the policy rate eventually falls below its baseline level, the drop is smaller than in the benchmark model. This causes a larger increase in the non-crisis unemployment rate, which now peeks at approximately 1 percentage points above baseline and only slightly falls below baseline in quarters 20-30.
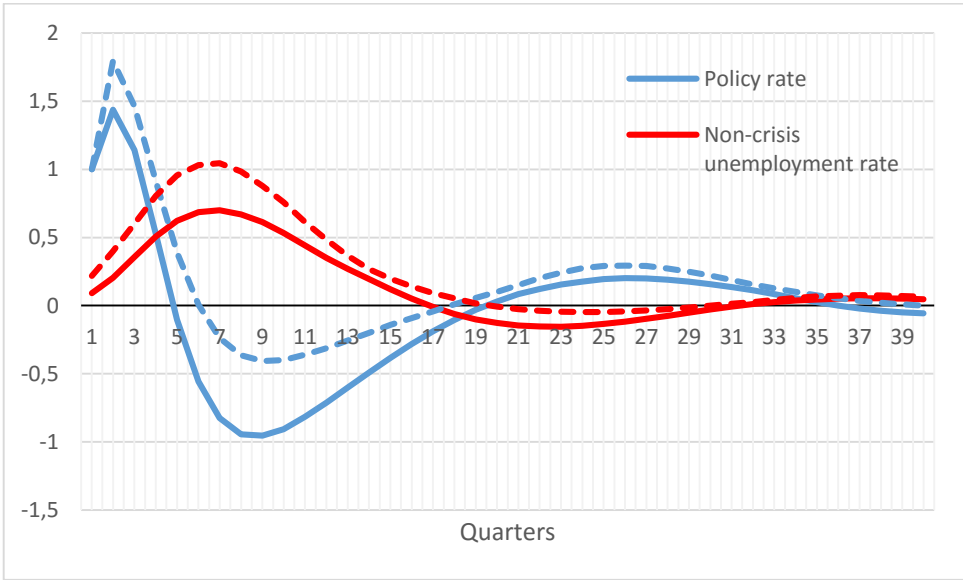

Figure 0.6: The effect of the monetary policy shock on the policy rate and the non-crisis unemployment rate when the upper bound estimate in the 67 % confidence band is used.

The sharper increase in the policy rate on impact leads to a sharper fall in the credit growth, and hence a larger deviation in the annual average credit growth from its baseline. The fact that the policy rate now remains above the median estimates used in the benchmark model, means that the credit growth remains below the estimates from the benchmark model for all 40 quarters after the monetary policy shock. The maximum deviation in the credit growth from its baseline is now 2.5 percentage points, compared to 1.2 percentage points in the

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[30] The upper and lower bound estimates refer to two different scenarios: An extreme scenario and a conservative scenario concerning the effect of the monetary policy shock on the policy rate. Thus, the extreme scenario is given by the upper bound estimates for the policy rate, which corresponds to the upper bound estimates for the non-crisis unemployment rate, and with the lower bound estimates for the credit growth.

benchmark model. This further implies a sharper fall in the crisis probabilities on impact, and they persistently stay below their counterparts from the benchmark model. The maximum deviation in the probability for a crisis in quarter t is doubled compared to the benchmark model, and is now 0.6 percentage points.

The development in the credit growth and crisis probabilities following the monetary policy shock is illustrated in the figure below for both the benchmark model (solid line) and in the extreme scenario (dotted lines). The larger monetary policy shock causes a larger drop in the credit growth, and thus a larger drop in the crisis probabilities. This larger reduction in the crisis probabilities pulls in the direction of increased benefit of leaning, and thus increased justification of leaning. However, the upwards shift in the non-crisis unemployment rate, caused by the larger monetary policy shock, pulls in the opposite direction by increasing the cost of leaning. It is uncertain how these two effects translate to the net marginal cost of leaning, since the quadratic loss function also includes the additional cost of leaning by forcing the economy to start out at a higher unemployment rate if a crisis were to occur.
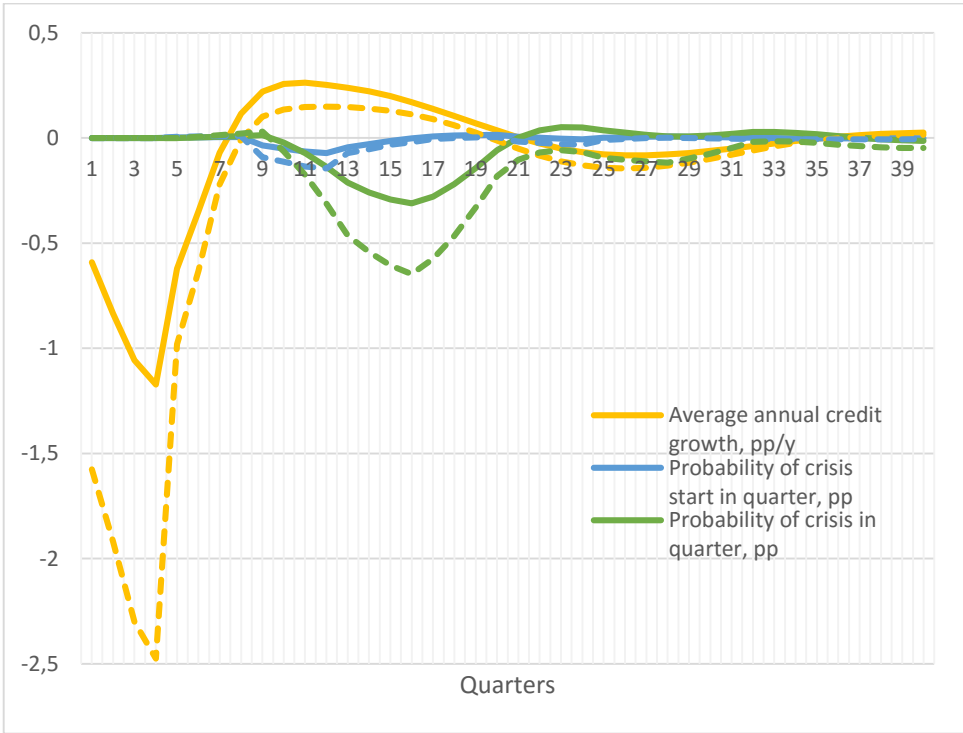

Figure 0.7: The effect of the monetary policy shock on average annual credit growth and the crisis probabilities, when the upper bound in the 67 % confidence band is used.
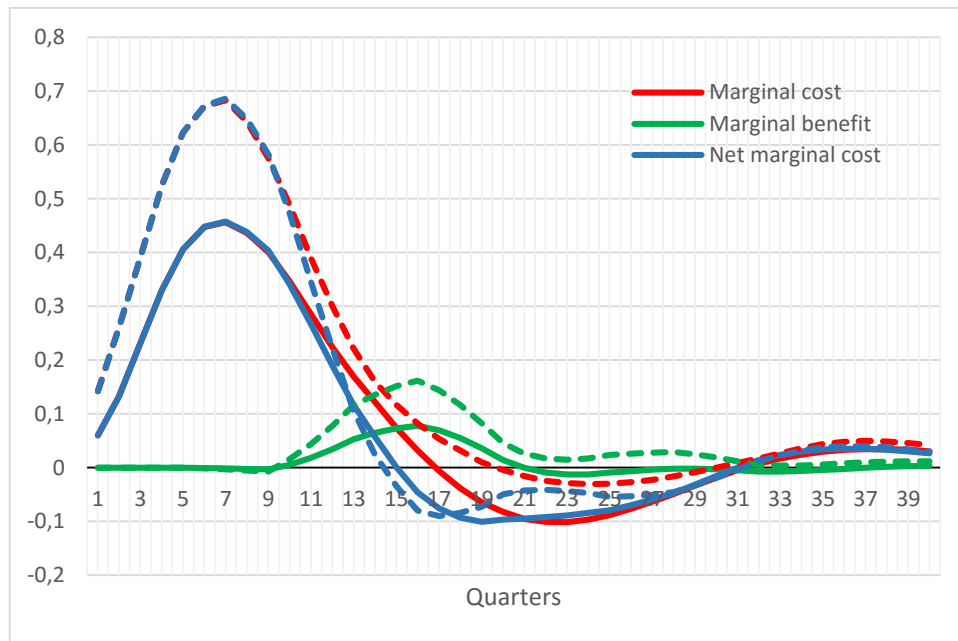
Figure 0.8: The development in the marginal cost, marginal benefit and net marginal cost of leaning following the monetary policy shock, when the upper bound estimates in the 67 % confidence band is used.

The figure above illustrates leaning evaluated by a quadratic loss function for both the benchmark model (solid lines) and for the extreme scenario (dotted lines). A stronger policy rate response leads to an upwards shift in the marginal cost of leaning since unemployment is now higher, but it also leads to an upwards shift in the marginal benefits since the stronger policy rate also induces a larger fall in the credit growth. In sum, the increase in the marginal cost is larger than the increase in marginal benefit, and the accumulated net marginal cost has increased[31]. In other words, the assumption of an extreme effect of a monetary policy shock on the policy rate, and thus on credit growth and crisis probabilities, does not alter the conclusion; leaning is still not justified.

The lower bound estimates from the 67 % confidence interval, referred to as the conservative scenario, produce a result in stark contrast to the results from both the benchmark model and from the upper bound estimates. In the figure below, we can see that in the conservative scenario, there is estimated a smaller increase in the policy rate on impact, and a subsequent larger fall below baseline around quarter 4. This causes a smaller increase in the non-crisis unemployment rate that now peeks at about 0.5 percentage point above baseline, and eventually falls somewhat further below baseline, compared to the benchmark model.

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[31] The accumulated net marginal cost is 5.14 in the extreme scenario. However, the cost in the extreme scenario is now only 4.7 times as large as the benefit, compared to 8.5 times larger in the benchmark model.
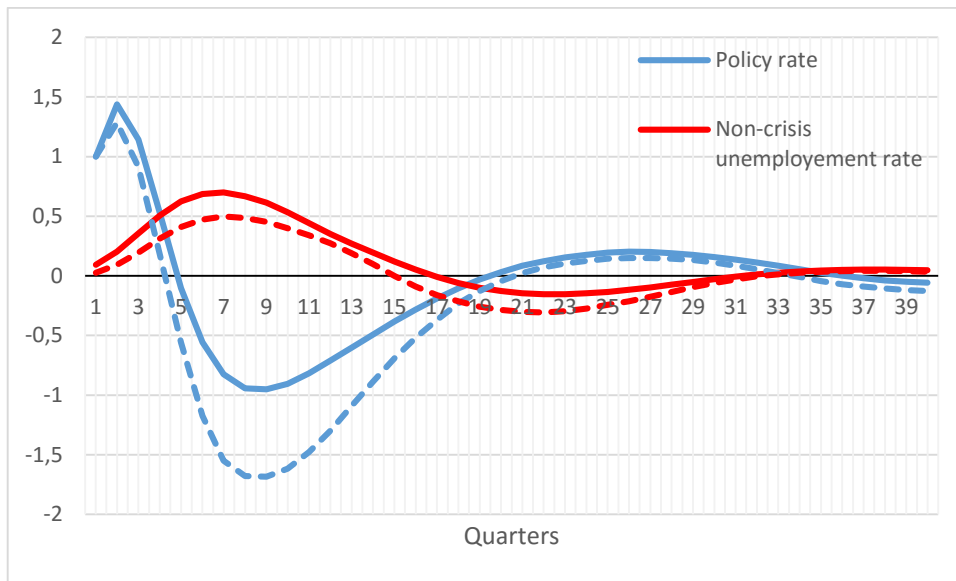
Figure 0.9: The effect of the monetary policy shock on the policy rate and the non-crisis unemployment rate when the lower bound estimate in the 67 % confidence band is used
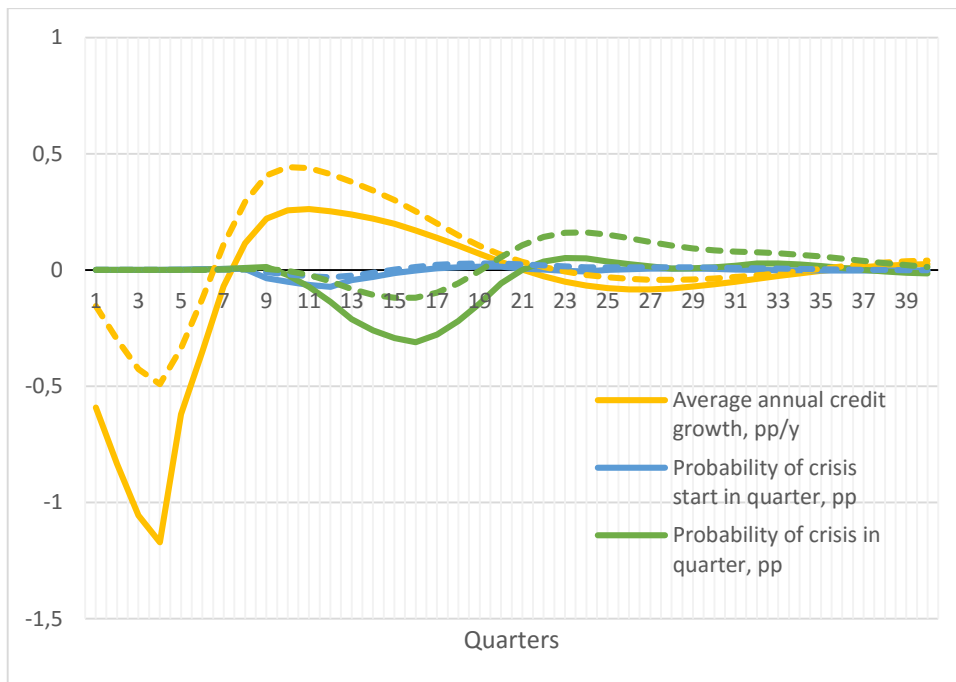

Figure 0.10: The effect of the monetary policy shock on average annual credit growth and the crisis probabilities, when the lower bound in the 67 % confidence band is used.

The smaller increase in the policy rate on impact and the following larger fall below baseline, implies a smaller drop in credit growth in response to the monetary policy shock. Not only is the fall in the annual average credit growth smaller than in the benchmark model, but the following increase above its baseline is also much larger than in the benchmark model. The same dynamic can be found in the crisis probabilities: A smaller initial drop in the

probabilities, than a larger increase above their baselines. In sum, the accumulated effect on the crisis probabilities appear to be zero in the conservative scenario.

Evaluating the model based on the lower bound estimates by the quadratic loss function, I find a marginal benefit that looks rather similar to the one found by Svensson. The large increase in the crisis probabilities following the initial decrease means that the marginal benefit will first be positive but then fall below zero. The accumulated marginal benefit in the conservative scenario is actually negative.

The smaller increase in the non-crisis unemployment rate, followed by the larger drop below its baseline, compared to the benchmark model, causes a downward shift in the marginal cost. In the conservative scenario, the net marginal cost follows almost exactly the development in the marginal cost. The net marginal cost will fall below zero around quarter 15, not because of the marginal benefit, but instead as a result of the non-crisis unemployment rate falling below its initial level. Even though the marginal cost of leaning has dropped significantly in the conservative scenario, the marginal benefit has now turned negative, causing a positive accumulated net marginal cost[32].
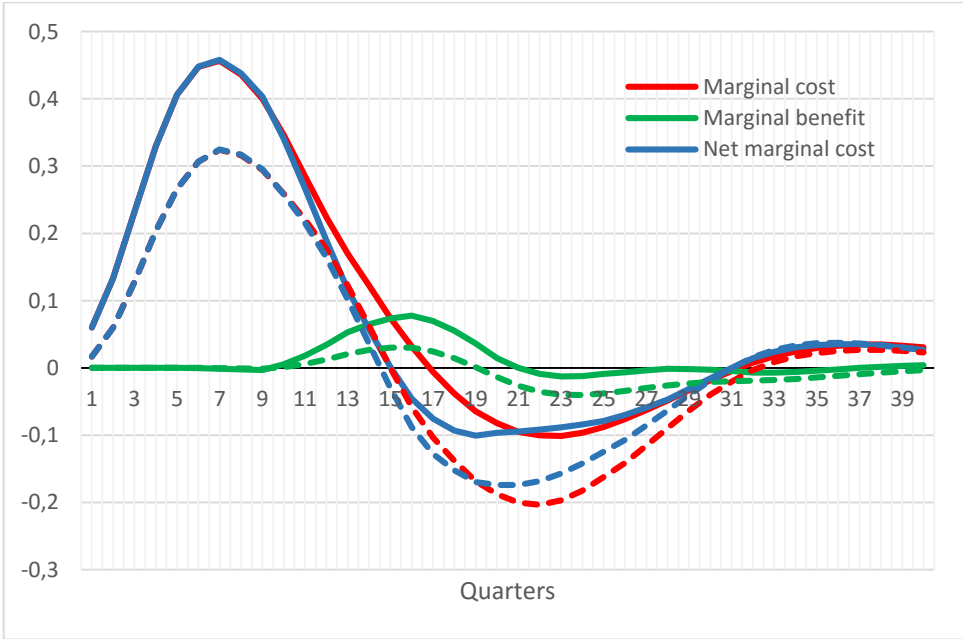

Figure 0.11: The development in the marginal cost, marginal benefit and net marginal cost of leaning following the monetary policy shock, when the lower bound estimates in the 67 % confidence band is used.

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[32] The sum of the net marginal cost is now 1.14. This is much smaller than in the benchmark model, and it is caused by the smaller increase in the non-crisis unemployment rate. However, the accumulated marginal benefit turns out to be negative. In other words, there are no benefit, only cost, of leaning in the conservative scenario.

Conclusion

Wide confidence bands in the estimates from the VAR model, causes some uncertainty in the results from the benchmark model. When estimating the model by using the upper and lower bound estimates from a 67% confidence bands, as opposed to the median estimates, produces quite different results. Both the marginal benefit and marginal cost increases in the case with the upper bound estimates, also referred to as the extreme case. The increase in the marginal cost is caused by a higher non-crisis unemployment rate, while the increase in the marginal benefit is caused by a larger reduction in the crisis probability. However, the increase in the marginal benefit is outweighed by the increase in the marginal cost, thus increasing the accumulated net marginal cost. In the case with the lower bound estimates, or the conservative case, the increase in the non-crisis unemployment rate is much smaller, which causes a downwards shift in the marginal cost. However, the accumulated effect on the crisis probability is approximately zero, causing a marginal benefit close to zero, and thus a positive accumulated net marginal cost. While there is still a benefit of leaning in the extreme case, the conservative case produces a dynamic in the crisis probability and marginal benefit close to the ones found by Svensson. Either way, the conclusion from the benchmark model is upheld in both cases.