The Publication of Interest Rate Projections by the Central Banks of Norway and Sweden

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Abstract

The publication of interest rate projections by central banks, a central bank’s own quantitative estimate of future interest rate decisions, is the newest and most controversial method of increasing transparency. Economists and central bankers disagree over whether or not publishing projections help the central bank manage private sector expectations. This paper examines if publishing interest rate projections by the central banks of Norway and Sweden improves the private sector’s ability to predict future interest rates. I investigate the effect of publishing projections on the root mean square error of money market forward rates and on changes in rates in response to interest rate decisions by the central bank. Using a New Keynesian macroeconomic model, I show that publishing projections should improve predictability if publishing provides the market with a clearer signal of future actions by the central bank. However, the empirical evidence suggests the effect of publishing projections may be negligible because interest rates were already relatively predictable and projections from both central banks have performed poorly during the financial crisis.

Keywords: Central bank communication, interest rate projections, Norges Bank, Riksbank

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1 Introduction

Central bank communication, the transmission of information from a central bank to the public, has undergone a considerable transformation in the past few decades. While secrecy about monetary policy was once considered a virtue, empirical and theoretical studies have suggested that increasing central bank transparency, the openness with which the central bank conducts its operations, has benefits (see van der Cruijsen and Eijffinger 2007). Central banks have used a variety of communication strategies to provide the public with greater information about their goals and operations. These steps include releasing statements explaining the rationale behind interest rate decisions, publishing minutes of monetary policy committee (MPC) meetings, announcing an inflation target and providing the central bank’s forecasts of key economic indicators. Most recently, and perhaps most controversially, several central banks have begun publishing projections of their key policy interest rate, the interest rate set by the central bank, up to three years into the future.

Publishing interest rate projections entails releasing quantitative forecasts for the future development of the key policy interest rate. (References to the interest rate refer to the key policy interest rate unless otherwise specified.) Interest rate projections are generally presented graphically. The central bank’s projections are distinct from forward interest rates derived through market expectations because the MPC of the central bank must agree on an interest rate path, a set of future interest rates, in the same way it sets the current interest rate. The interest rate projections should be the central bank’s best estimate of its future interest rate decisions based on the information the bank has available at the time of the projections. Publishing these projections provides additional transparency because market participants receive more information on the central bank’s understanding of the economy and how the central bank anticipates acting. This knowledge can then be used to better estimate the central bank’s reaction to increases in inflation or unemployment.

The practice of publishing interest rate projections is considered controversial for several reasons. First, there is no clear consensus in the current literature about whether publish-
ing interest rate projections leads to positive outcomes. Since publishing projections is a relatively new phenomenon and the empirical evidence is limited, most research has been theoretical, with different authors and models reaching conflicting conclusions. Section 2.2 summarizes the debate over publishing interest rate projections. Second, discussing future interest rates has been characterized as one of the strongest taboos of central bank communication (Faust and Leeper 2005). Even now, few central banks publish projections or explicitly discuss future interest rates. The evidence in support of some level of central bank transparency and the uncertainty surrounding the effects of the publication of interest rate projections demonstrate the need for additional research on the topic and suggest the basis for the taboo should be investigated.

The Reserve Bank of New Zealand (RBNZ) first began publishing interest rate projections in 1998, followed by the Norges Bank (the central bank of Norway) in 2005, the Sveriges Riksbank (the central bank of Sweden) in February 2007, the Sedlabanki Islands (the central bank of Iceland) in March 2007 and the Czech National Bank in 2008 (Svensson 2008b). This paper focuses on the publication of interest rate projections by the central banks of Norway and Sweden (the justification for the selection of these two central banks is discussed in Section 3.1). I use a New Keynesian macroeconomic model similar to that of Woodford (2003) to examine the effect of publishing interest rate projections on the performance of market expectations of future interest rates. From a theoretical perspective, I find that if publishing interest rate projections reduces the transmission noise, the noise that occurs as the central bank communicates its intentions to the public, then publishing projections should improve the private sector’s ability to predict future interest rates. Improving the private sector’s ability to predict interest rates can help the central bank better manage market expectations of interest rate changes. I test whether publishing interest rate projections has reduced the root mean square error (RMSE) of money market forward rates compared to the realized overnight rate. I also examine if absolute changes in market interest rates following announcements of interest rate decisions by the central bank have declined since the Norges
Bank and Riksbank began publishing inflation targets. I conclude that the limited empirical evidence currently available suggests publishing interest rate projections has had a negligible effect on the ability of the private sector to anticipate future market interest rates.

The rest of this paper is organized as follows: Section 2 defines optimal monetary policy, summarizes the debate over publishing interest rate projections and reviews recent literature on Norway and Sweden; Section 3 provides justification for the selection of the Norges Bank and Riksbank, details the manner in which the Norges Bank and Riksbank have gone about publishing their projections and examines the performance of their projections; Section 4 describes, solves and offers testable implications of the theoretical model; Section 5 provides and discusses the results of these tests; and Section 6 concludes. Tables and figures can be found in the Appendix (Section 7).

2 Literature Review

The literature review comes in three parts: first, a discussion of the goals of central bank communication; second, a summary of the debate for and against the publication of interest rate projections; and third, an examination of previous work that has looked at the publication of interest rate projections in Norway and Sweden. Reviewing the current literature will show that there is still considerable scope for research related to the publication of interest rate projections, in part because there is no clear consensus in the theoretical literature about the benefits of publishing projections.

2.1 Optimal Monetary Policy and Central Bank Communication

To understand whether or not the publication of interest rate projections is beneficial to the economy, one must first address the goals of monetary policy and central bank communication. For flexible inflation-targeting central banks, monetary policy is typically described
as a loss function of the form (see Svensson 2008b; Woodford 2003):

\[ L_t = (\pi_t - \pi^*)^2 + \lambda (y_t - \hat{y}_t)^2, \]  

(1)

where \( L_t \) is the loss in period \( t \); \( \pi_t \) is the inflation rate at time \( t \), \( \pi^* \) is the inflation target, a constant target across all periods; \( y_t \) is the logarithm of total output and \( \hat{y}_t \) is the logarithm of potential output. The output gap, the difference in actual and potential output, is defined as \( x_t \equiv y_t - \hat{y}_t \). The parameter \( \lambda \) signifies the weight the central bank places on deviations in the output gap with respect to deviations from the inflation target. The central bank’s objective is to minimize this loss function, which will occur when the inflation rate is at its target and the economy is producing at its potential output.

It is from this loss function that the central bank seeks to develop optimal monetary policy. Woodford (2003) shows that the central bank can benefit by committing to a set reaction function. Commitment to a policy of this sort eliminates the time-inconsistency problem. The time-inconsistency problem occurs when the central bank makes decisions based on what is best for it at the present time, rather than making decisions based on what will be best in the future. By acting in a predictable manner, the central bank ensures that the market’s expectations remain consistent even when the economy faces shocks. Woodford (2003) provides theoretical evidence of the manner in which an optimal commitment to policy can offset unexpected cost-push shocks to inflation. This is contrasted with a strategy of minimizing the loss function in each period, which builds the shock into the price level (see Figure 7.3, p. 494).

Optimal monetary policy that avoids the time-inconsistency problem is frequently referred to as “optimal from the timeless perspective” (Woodford 2003; Holmsen, et al. 2008). It is an interest rate reaction function that minimizes the loss function across all periods, abstracting away from the current period. This abstraction is necessary because the central bank is faced with a time-inconsistency problem in the present period. The central bank
seeks to select parameter values for its interest rate reaction function that would result in
the smallest amount of social loss across all periods, then commits to this reaction function
so that the central bank responds predictably in each period. By committing to an interest
rate reaction function that is timelessly optimal, the central bank can (theoretically) achieve
the smallest total loss.

Once the central bank has determined its optimal monetary policy, it must decide how to
best interact with the market; this is where the importance of central bank communication
enters. Issing (2005) notes that transparency and communication are secondary goals to the
central bank’s mandate of maintaining price stability. Communication is important insofar as
it can be used to help the central bank meet its objectives for inflation and output. Woodford
(2005) argues that little other than managing expectations matters for monetary policy, and
communication from the central bank is the way in which central banks influence market
expectations. However, there are no clear “best practices” in central bank communication
(Blinder, et al. 2008, p. 56), making research on the relatively new development of publishing
interest rate projections a “high-priority area for future research” (p. 58).

In the absence of clear “best practices,” Blinder, et al. (2008) nevertheless find that
communication can better manage expectations by “creating news” and “reducing noise”
(p. 4). This means that information provided by the central bank should be notable and
of interest to the public, while simultaneously being as clear as possible. A central bank
should value clarity so as not to confuse its audience and distort the signal the central bank
is attempting to send with its communication. By creating news and reducing noise, the
central bank can use its communication to manage market expectations and most easily
achieve its monetary policy mandate. If publishing interest rate projections meets these two
criteria, then publication could help the central bank better manage market expectations.
However, there is considerable debate as to whether or not this is the case, the topic to which
I now turn.
2.2 The Debate Over Publishing Interest Rate Projections

There is no clear consensus whether the overall effect of publishing interest rate projections is positive or negative in the theoretical literature. This debate is frequently included in more general discussions on the merits and ideal limits of central bank transparency. Proponents of the publication of interest rate projections argue that this additional communication is vital to the central bank’s objective of managing expectations, which Woodford (2005) defines as the main task of the central bank. Rudebusch and Williams (2006) state, “the current policy rate is most relevant to the extent it conveys information about future policy settings and influences longer-maturity interest rates” (p. 1). Svensson (2006b) makes a similar point when he argues that the correct way to understand the transmission of monetary policy into the financial markets is a “mapping from an instrument-rate path to target-variable paths, not as a mapping from a current instrument-rate level to a level of the target variables at some particular horizon” (p. 183). By aligning private sector expectations with the outcomes the central bank desires, the central bank can use the self-fulfilling nature of expectations to help meet its monetary policy objectives. At its simplest level, proponents of publishing interest rate projections argue publishing projections better manages private-sector expectations because it gives the private sector information on how the central bank believes the interest rate path will evolve, rather than requiring the private sector to come up with its own expectations given the current interest rate.

Svensson (2007) expands this idea and presents the argument in favor of publishing interest rate projections. Central banks normally announce the interest rate that will be in operation until the next MPC meeting, which is generally four to eight weeks later. However, market expectations of future interest rates are based upon the entire path of the short-term interest rate, not solely on the interest rate for the next two months. Since the entire interest rate path matters for private sector decisions, the MPC should be debating an explicit interest rate path at its meetings because this will influence the private sector’s economic outlooks and forecasts. As touched on before, forecasts for future output and
inflation depend upon future interest rate changes and are therefore more accurate when they incorporate the central bank’s estimation of the most likely interest rate path (Svensson 2006b). Additionally, a central bank can consider itself successful at managing expectations when market expectations are aligned with those of the central bank. If a central bank does not publish its optimal interest rate path, it is withholding the most important information for managing market expectations from the market (Svensson 2007). Therefore, Svensson (2007) concludes that the “[d]iscussion, selection, and publication of interest rate path is only right thing to do” (p. 21).

However, critics would argue that publishing interest rate projections may not be the best way to manage private sector expectations due to the possible distraction these projections could cause. Central banks have a vast amount of information that could be published and must decide what information would be most helpful to fulfill their mandates. Issing (2005) notes that potential publishable information is not self-explanatory and often subject to later revision. The hypothesis that publishing all of this information would increase the amount of noise for all but the most savvy consumers of central bank information seems plausible.

Dale, Orphanides and Österholm (2008) provide an example of how publishing forecasts could create more noise in the context of inflation forecasts. They note that central banks know some information with more certainty; for example, the inflation target is known much more concretely than the quarterly inflation rate two years into the future. The authors emphasize that a great deal of the information communicated by central banks is inherently imperfect and noisy and will only further the private sector’s understanding of the economy if it is correctly interpreted. Using a theoretical model emphasizing imperfect knowledge on the part of both the central bank and the private sector, the authors find that it is better for the central bank not to publish inflation forecasts when central bank forecasts cross certain thresholds for accuracy relative to the private sector forecasts and the private sector’s ability to assess their quality. They also find that announcing an inflation target can “crowd out” the importance of publishing inflation rate forecasts, suggesting that inflation forecasts add
little valuable information in the presence of an explicit inflation target. Since the inflation target is known with greater certainty than the inflation forecast, this implies that it may be better for the central bank to focus on releasing information about which it is more certain. On a separate note, Dale, Orphanides and Österholm (2008) also remark that as more information is communicated, the likelihood that the last marginal piece of information is distracting increases.

In response, Svensson (2008a) stresses that the results of Dale, Orphanides and Österholm (2008) only hold when both the central bank’s forecast is worse than the private sector’s forecast and the private sector mistakenly believes that the central bank’s forecast is good. He finds that both conditions frequently do not hold in practice: central bank forecasts are often relatively good since central banks typically have more resources than any single private-sector forecaster and the private sector must place a very heavy weight on a central bank forecast that performs quite poorly with respect to private sector forecasts in order for publishing inflation forecasts to have a negative effect. Additionally, since Dale, Orphanides and Österholm (2008) address the issue of inflation forecasts, the central bank also has the informational advantage of its projected future interest rates over the private sector, which would make it even more difficult for the central bank forecast to be sufficiently poor relative to the private sector forecast. However, Svensson (2008a) does not address questions related to the magnitude of the improvement with publishing projections, leaving open the possibility of crowding out noted by Dale, Orphanides and Österholm (2008).

Faust and Leeper (2005) directly address the issue of publishing forecasts for key variables such as inflation. They find that the private sector has difficulty collecting valuable information about future changes in the key policy interest rate from forecasts based on constant interest rate or market expectations of interest rate assumptions. They characterize forecasts based on these assumptions as “conditional” forecasts since they are conditional to the assumption made about interest rates, whereas “unconditional” forecasts are based on the central bank’s projection of the interest rate path. Faust and Leeper (2005) note that
many central banks publish reports providing conditional forecasts in an attempt to increase transparency, but demonstrate through a theoretical model that central banks would be better off publishing unconditional forecasts of the interest rate and target variables due to the challenges inherent in deriving unconditional forecasts from conditional forecasts. In the terms of Blinder, et al. (2008), publishing unconditional forecasts and interest rate projections reduce the noise associated with the publication of inflation reports. Faust and Leeper (2005) also postulate that unconditional forecasting may in fact be easier than conditional forecasting for central banks because it involves fewer assumptions.

Many critics would disagree with Faust and Leeper (2005) that creating forecasts based on interest rate projections would be easier than using conditional forecasts. Publishing interest rate projections requires MPCs to agree on an interest rate path for the next two to three years. However, there are frequently disagreements about the rate until the next MPC meeting. Goodhart (2001) questions whether an MPC could ever come to a consensus given the “virtually infinite set of possible time paths, delivering convergence to the inflation target at a wide range of policy horizons” (p. 172). This concern is echoed in Mishkin (2004), who notes that while the argument in favor of publishing the interest rate path in order to develop forecasts for target variables has solid theoretical underpinnings, in practice it could cause difficulties in the decision-making process of the MPC. There are limited resources (in some cases, time) for the MPC to decide on an interest rate, and devoting resources to debates over future interest rates could compromise the discussion of present conditions. Both Goodhart and Mishkin have served on and observed MPCs at the Bank of England and Federal Reserve, respectively; therefore, they have seen the challenges of deciding on short-term rates firsthand.

Proponents of publishing interest rate projections point to the ability of the Norges Bank and Riksbank to reach consensus on an interest rate path with MPCs. In the past, the Reserve Bank of New Zealand was the only central bank publishing interest rate projections. Monetary policy at the RBNZ is set by its Governor, removing the challenge of building
consensus about rate changes. Since the Norges Bank and Riksbank have been able to publish interest rate projections with MPCs, they have proven that it can be done (Svensson 2008b). However, the MPCs of the Bank of England and Federal Reserve are both larger than those of the Norges Bank and Riksbank and, as Svensson (2008b) admits, the Riksbank has an advantage because all the members of its MPC are located in one place. There could be additional challenges for a central bank such as the Federal Reserve, with twice as many voting committee members spread across the country. However, Svensson (2002) proposes a method of aggregating individual preferences that he believes will hold even for larger MPCs. His method involves an iterated median voter model process until the interest rate projection converges to a result that can be agreed upon by the committee. While Mishkin (2004) is doubtful of the potential success of this sort of mechanism, the feasibility of publishing interest rate projections for central banks with MPCs is an important topic in the debate.

Rudebusch and Williams (2006) find that greater transparency, namely the publication of interest rate projections, helps the private sector better estimate the central bank’s reaction function and therefore improves the predictability of central bank actions. Their paper uses a theoretical model based on Woodford (2003) where private agents must learn about the central bank’s policy rule. They vary the transmission noise, a variable that models the public’s potential misunderstanding of central bank communication. They define a different amount of transmission noise for different types of communication, with greater transparency corresponding to reduced transmission noise. Therefore, Rudebusch and Williams (2006) assume that publishing interest rate projections gives private agents a clearer picture about the central bank’s policy rule than hints about future policy. This is a critical assumption that ignores the potential distraction publishing projections could cause. They then use their model to determine how changes in transparency affect private agents’ ability to learn and to estimate the central bank’s policy rule. Greater transparency (for example, moving from hints to an interest rate forecast) reduces the error and helps the market to better estimate the policy rule used by the central bank for setting interest rates. This suggests
that communicating interest rate projections can aid private sector learning and increase central bank predictability, offering support for the publication of interest rate projections.

Some critics are concerned about coordination on suboptimal equilibrium along the lines described in Morris and Shin (2002). Their paper presents a model in which part of an individual’s return comes through coordination with the market. In other words, there is a cost associated with deviating from market expectations. The authors worry that if private information is more precise than public information, agents will elect to base their expectations on the public information because of the benefits of coordination rather than their own, more accurate private information. This would result in an inefficient coordination on suboptimal expectations due to increased communication by the central bank. This is especially relevant in the context of publishing interest rate paths: if agents expect the market to take the projected rates as a commitment or if there is a cost associated with deviating from the projections, the market could coordinate to an inefficient equilibrium. However, subsequent work by Svensson (2006a) shows that for these results of Morris and Shin (2002) to apply, the signal-to-noise ratio of private information must be much greater than that of the central bank, and he claims this assumption is rarely realistic. This means if the central bank has comparable or better information than the market, the adverse coordination problem should not be an issue. Since most central banks in the developed world have large, sophisticated monetary policy and research departments, Svensson (2006a) argues that the results of Morris and Shin (2002) do support a degree of greater transparency, a finding echoed by a majority of the later research based upon Morris and Shin (2002).

Finally, there are concerns that the central bank will be constrained in its decision-making by publishing an interest rate projection because future changes in the interest rate that deviate from the projection, even though they may be optimal, will result in a loss in credibility (Mishkin 2004). Issing (2005) also sees challenges in convincing the private sector of the conditionality of forecasts ex-ante. There can be a cost associated with changing course, even when the change is based on newer, more accurate information. Therefore,
some critics feel it would be better for the central bank not to risk losing credibility, as credibility is necessary for the central bank to be able to manage expectations.

Proponents counter that there is no empirical evidence from New Zealand, Norway or Sweden to indicate that markets have not understood that interest rate projections are not commitments but rather forecasts (Rudebusch and Williams 2006; Svensson 2008b). In fact, the Riksbank frequently repeats, “It is a forecast, not a promise” (Svensson 2008b, p. 13). The use of fan charts also helps convey that the interest rate is subject to change given other economic developments and that projections are more of a distribution than a point estimate. In this way, the central bank displays less commitment to a particular path.

2.3 Recent Studies on Norway and Sweden

Svensson (2006b) examines the publication of interest rate projections in Norway shortly after they were implemented. He primarily discusses the benefits of creating and publishing interest rate projections for forecasts of inflation and other macroeconomic variables. He emphasizes the weaknesses of developing forecasts based on constant interest rate assumptions or market expectations. Neither approach presents the central bank’s best forecast of the future development of target variables because they do not incorporate the central bank’s best forecast of future interest rate changes. Svensson (2006b) concludes that publishing and using interest rate projections in forecasts for target variables provides the public with the best information about future interest rates, and therefore other central banks should follow the Norges Bank’s lead.

Holmsen, et al. (2008) present an insider perspective of the Norges Bank’s publication of interest rate projections. All the authors are members of the Norges Bank and one co-author, Jan Qvigstad, is currently Deputy Governor. Their paper discusses the debate about publishing interest rate projections and highlights distinctive aspects of the Norges Bank’s communication strategy. Additionally, they find that the average change in money market interest rates in response to interest rate decisions declined after the publication of
projections. However, the difference was not statistically significant for most maturities. They found that releasing a “strategy interval,” typically of one percent, between which the interest rate should remain for the next four months, was a statistically significant breakpoint for many maturities. This suggests that the publication of information about future interest rates, in the form of projections or strategy intervals, may help better manage expectations over the near term.

Svensson (2008b) reflects on his experience as the Deputy Governor of the Riksbank since being appointed in May 2007. He graphically examines movements in forward rates following the release of new interest rate paths. He concludes that as time went on, the private sector seemed to take the projections more seriously. He observes that forward rates have been more closely aligned with the projected rates after recent reports. However, the uncertainty surrounding the global economy from the current crisis has overshadowed many of the reports since the Riksbank began publishing interest rate projections, potentially making markets more skeptical of the Riksbank’s projections. Svensson (2008b) also highlights a unique aspect of transparency at the Riksbank, the release of attributed minutes of MPC meetings. The Riksbank is currently the only central bank to do this. The paper also contains extracts on the official communication strategy and guidelines for communication by members of the Riksbank.

While these studies of the Norges Bank and Riksbank focus on the benefits of publishing projections, they do not answer some of the main objections to publishing projections. The current literature on Norway and Sweden does not address whether or not there has been a loss in credibility because of publishing projections or the magnitude of potential gains from publishing projections. These studies also do not answer whether similar results could be obtained without publishing, along the lines of the crowding out effect detailed by Dale, Orphanides and Österholm (2008).

The debate over the merits of publishing interest rate projections is far from over. Despite the advocacy on the part of certain proponents, many central banks seem reluctant to adopt
the new measures. Since there is no theoretical consensus and little empirical evidence, additional research on this topic is needed. My paper enters into this debate and aims to analyze the effect of publishing interest rate projections on market expectations of interest rates in Norway and Sweden.

3 Interest Rate Projections in Practice

This section begins by discussing the rationale behind the focus on the central banks of Norway and Sweden. Their actions are placed in the context of the conduct of monetary policy by central banks from around the world. Next, this section describes how the Norges Bank carries out publishing interest rate projections, including an examination of the content of the reports containing interest rate projections. I also analyze the performance of the Norges Bank interest rate projections. I then conduct the same investigation for the Riksbank.

3.1 Why Norges Bank and Riksbank?

The practice of publishing interest rate projections is distinct from the communication strategies of many other central banks. Characteristics of the Norges Bank and Riksbank set these two central banks apart from other central banks that publish interest rate projections. As mentioned before, there has been a general trend towards increased transparency over the past several decades. One key development in this process was inflation targeting, where central banks announce the quantitative inflation target they hope to achieve through their monetary policy. Most central banks have a mandate to maintain price stability; maintaining inflation around a low target is one way to keep prices stable. If the central bank can credibly achieve its target, markets should align their long-term inflation expectations with the central bank’s target. There is evidence that inflation targeting can anchor long-term inflation expectations (Gürkaynak, et al. 2007), meaning inflation targeting can help manage
market expectations for inflation.

Inflation-targeting central banks can be either strict or flexible inflation targeters. Strict inflation-targeting central banks set monetary policy based solely on the considerations of the inflation rate with respect to its target. Since central banks consider other factors in addition to inflation, strict inflation targeting is a theoretical idea rather than a practical one. It offers beneficial examples of how announcing an inflation target provides information to the private sector. For example, if the inflation rate is above the target, the central bank should tighten monetary policy by raising interest rates in an attempt to lower the inflation rate. Likewise, when inflation is below the bank’s target, one could expect rates to decline due to greater monetary policy accommodation. Therefore, announcing an inflation target can help the private sector better anticipate future central bank actions.

Flexible inflation-targeting central banks announce a quantitative inflation target, yet also consider deviations in actual output from potential output when formulating monetary policy. Flexible inflation-targeting central banks may be willing to tolerate an inflation rate above their target if this helps reduce fluctuations in output. In practice, this is the type of monetary policy conducted by inflation-targeting central banks, such as the European Central Bank (ECB). This is distinguished from the practices of the Federal Reserve by the publicly announced quantitative inflation target.

Currently, all of the central banks that publish interest rate projections are flexible inflation-targeting central banks. The practice of publishing interest rate projections sets these central banks apart from other flexible inflation-targeting central banks. Additionally, several features of the Norges Bank and Riksbank distinguish these two central banks from other projection-publishing central banks. The Norges Bank and Riksbank decide upon monetary policy by committee rather than by an individual, as in this case of the RBNZ. The MPCs of the Norges Bank and Riksbank, both called the Executive Board, are made up of seven and six members, respectively. Examining the practices of central banks of Norway and Sweden could help address questions about the feasibility of publishing interest rate
projections for central banks with MPCs. Second, both the Norges Bank and Riksbank use fan charts in connection with their projections, whereas the RBNZ does not. These illustrate the probability of given interest rates in the future while showing that the interest rate projections are not fixed in stone, but rather dependent upon future changes in the economy. Focusing on the experience of the Norges Bank and Riksbank could address whether or not central banks feel constrained by projections incorporating fan charts. The related criticism that markets will not understand the conditional nature of these forecasts (and therefore damage the credibility of the central bank that is publishing them) could also be better examined by focusing on the practices of the Norges Bank and Riksbank.

The Czech National Bank and Sedlabanki Islands share the aforementioned features of interest rate publishing with the Norges Bank and Riksbank. However, the Czech National Bank did not begin publishing projections until 2008, while the central bank of Iceland has been forced to take actions it may not have normally taken due the large impact of the financial crisis on Iceland. Sedlabanki Islands adopted an interim goal of stabilizing the exchange rate, shifting its inflation target to a long-term goal (Sedlabanki Islands 2009). This temporary change in strategy limits the number of observations that could be broadly compared. Therefore, this paper focuses on the Norges Bank and Riksbank because they provide the greatest number of observations while maintaining the qualities of interest described in the previous paragraph. Their importance is confirmed by Blinder, et al. (2008), where the Norges Bank and Riksbank were described as the “vanguard” of transparency (p. 4).

3.2 Norges Bank

3.2.1 Background and Reports

The Executive Board of the Norges Bank, its monetary policy committee, sets Norwegian monetary policy. The Executive Board consists of seven members appointed by the Norwegian government, chaired by the Central Bank Governor and Deputy Central Bank Governor (Norges Bank “The Executive Board”). The Executive Board uses the sight deposit rate,
the rate at which interest is paid on deposits with the central bank, as the interest rate for Norwegian monetary policy. The sight deposit rate serves as the floor for short-term money market rates because no financial institution would be willing to lend for less (Norges Bank “Norges Bank’s Key Policy Rate”). The Executive Board also approves the Monetary Policy Report (MPR) published by the Norges Bank. These reports are issued in March, June and October or November and contain an assessment of the current economic situation and, more recently, the bank’s interest rate projections. Prior to 2007, these publications were called Inflation Reports (IRs), emphasizing the Norges Bank’s previous focus on meeting its inflation target. In 2007, the reports were renamed Monetary Policy Reports to better reflect the purpose of the report in light of the continued publication of interest rate projections: providing transparency to the private sector about the Norges Bank’s assessment of the economy, its future actions and the justification for these actions and changes from the last report (Juel, Molnar and Røad 2008).

The Norges Bank has been a flexible inflation-targeting central bank since March 29, 2001, when the Norwegian parliament adjusted the Norges Bank’s mandate to include an inflation target of 2.5 percent per year (Norges Bank “Monetary Policy”). The Norges Bank currently aims to keep inflation close to the target in the “medium term.” The medium term is generally understood to be one to three years because that was the stated time frame before the wording was changed to medium term (Juel, Molnar and Røad 2008). In July 2004 the Norges Bank began publishing forward-looking “strategy intervals,” the interval in which it expected to maintain the interest rate in the next four months. The interval is generally one percentage point and many in the private sector use the midpoint of the interval as a point estimate of the interest rate four months into the future (Holmsen, et al. 2008). The release of strategy intervals communicated information about the short-term future path of the sight deposit rate, serving as a precursor to the more specific, medium-term interest rate projections the Norges Bank would later publish.

In November 2005, the Norges Bank became the second central bank (after the Reserve
Bank of New Zealand) to publish projections of its interest rate in IR 3/2005 (Holmsen, et al. 2008). Projections of the sight deposit rate use fan charts to illustrate that the projections are subject to change as new information becomes available. While the Norges Bank published some type of inflation forecast for over a decade, it has consistently published fan chart projections for the inflation rate and output gap since IR 3/2005. Since the Executive Board considers both inflation and output fluctuations when setting the sight deposit rate, knowledge of the manner in which the Norges Bank expects these variables to develop can offer additional clues about the trajectory of future interest rates.

The Norges Bank’s most recent projections for the sight deposit rate, output gap, consumer price index (CPI) and a measure of core CPI from the Norges Bank’s first Monetary Policy Report of 2009 are presented in Figure 1. The solid black line represents actual past values while the dotted black line represents the bank’s projection for baseline case, the scenario the Norges Bank views as most likely. The bands of the fan chart indicate confidence intervals for the projections, with darker bands corresponding to lower confidence intervals. The darkest band represents a thirty percent confidence interval, the next a fifty percent confidence interval, followed by a seventy percent confidence interval and finally a ninety percent confidence interval.

Absent additional shocks, the Norges Bank predicts that implementing the projected sight deposit rate will result in the output gap returning to zero and the inflation rate returning to its target in 2012, within the Norges Bank’s medium term. The ninety percent confidence interval of the forecast of the sight deposit rate three years into the future has a range of approximately six percentage points, a wide margin that would indicate distinctly different developments in inflation and the output gap. An interesting feature of the Norges Bank’s forecast of the output gap is the inclusion of confidence intervals for realized values (Figure 1.b). This component of the Norges Bank’s forecasts reflects the difficulty in measuring the output gap with certainty due to the frequent and potentially large ex-post revisions that can occur. This speaks to a larger point about the difficulty of obtaining accurate real-time
data on economic indicators. All central banks face this challenge regardless of whether or not they publish interest rate forecasts because interest rate decisions are based in a large part on real-time data. However, errors made by the Norges Bank in estimating the output gap and other variables in real time are perhaps more visible than in other central banks due to their role in projections and reports released by the Norges Bank.

The Norges Bank also includes projected interest rates and target variables for alternative scenarios where economic conditions develop differently than the baseline scenario. An example from MPR 1/2009 is shown in Figure 2. The Norges Bank sees the potential for higher or lower demand having a noticeable impact on future interest rates. In the alternative case of higher demand, rates could be set outside of the seventy percent confidence interval in the months after the report was released. This change in interest rate projections under alternative scenarios can be contrasted with the inflation rate in high or low demand scenarios. In either alternative scenario, the Norges Bank expects inflation to decline for the next year almost in lock-step with its baseline scenario. The Norges Bank is much more confident about the path of inflation than the path of interest rates.

Another interesting inclusion in the Norges Bank’s reports are what it calls the “interest rate account” (Holmsen, et al. 2008), depicted in Figure 3. The Norges Bank uses its macroeconomic model to characterize the contributions of specific factors to changes in the interest rate projection from the previous report. For example, the projected interest rate for the second quarter of 2009 declined by 2.56 percentage points from MPR 3/2008 to MPR 1/2009. The Norges Bank’s model attributed -1.56 percentage points of the decline to changes in demand (in this case, lower demand), -0.86 percentage points from changes in prices and costs and -0.8 percentage points from lower interest rates abroad. This was offset by a 0.65 percentage point suggested increase in rates from changes to the exchange rate.\footnote{The “interest rate account” figure was taken from the report released by the Norges Bank, while the numerical values come from the underlying data. This is released in conjunction with the report in spreadsheet form and available on the Norges Bank website.} Another way of thinking about this would be that in the absence of changes in other
factors, the change in demand, for instance, would have caused interest rates to change by the amount illustrated in the red bars. Holmsen, et al. (2008) notes that since these numbers come from the Norges Bank’s model, they should not be taken as enumerating the “reaction pattern” of the Executive Board (p. 12). However, the illustrations do provide insight into the central bank’s reaction function, quickly summarize the present report and communicate the commitment of the Norges Bank to a time-invariant optimal policy by showing how the Executive Board responds to news rather than re-optimizes the reaction function (Holmsen, et al. 2008).

The reports issued by the Norges Bank describe the Executive Board’s view of the current economy to the private sector in a manner that attempts to be detailed and transparent. The projections released by the bank, along with the alternative scenarios and interest rate account, provide the public with quantitative information about potential future interest rates. The next section begins to examine the quality and accuracy of the interest rate projections contained in the reports.

3.2.2 Performance of Projections

One would expect the benefits of publishing interest rate projections to depend in part on the performance of the projections. Graphical assessments of the performance of the Norges Bank interest rate projections demonstrate how closely the realized sight deposit rate was to the point estimates and confidence intervals of the projections. Figure 4 contains projections from the third Monetary Policy Report of each year from 2005 to 2008. The solid black line represents the realized sight deposit rate, while the dotted black line represents the baseline scenario of the projection. The realized quarterly sight deposit rate fell within the quarterly point estimates of the thirty percent confidence interval for the first four quarters for each of these reports other than 2008. As the projections move further into the future, there appears to be a greater degree of divergence between the interest rate projection and realized sight deposit rate. However, this is hardly surprising as it is harder to anticipate the magnitude
and persistence of shocks further into the future.

There are several ways one could view the large divergence between the projections and the realized sight deposit rate in late 2008 to 2009. It could illustrate the extraordinary circumstances of the global economy in the financial crisis and offer insight into the magnitude of the effect of the crisis on Norway. This view would find realized interest rates outside of the ninety percent confidence interval of the Norges Bank’s forecasts indicative of the severity of the crisis and of the low probability of a shock of the magnitude of the crisis. However, one could also question the usefulness of publishing projections when, as was the case in MPR 3/2008, the interest rate was well below the lower bound of the ninety percent confidence interval just two quarters after the report was published. It seems as though it would be challenging to manage market expectations in cases with changes of this magnitude because it reduces the horizon over which the projections provide useful information. Once the realized sight deposit rate falls outside of the ninety percent confidence interval of a specific projection, the private sector is unlikely to put much weight on that particular projection.

A quantitative way to examine the accuracy of the Norges Bank’s interest rate projections is the root mean square error of the projections. The sample RMSE is calculated by taking the square root of the squared difference between its forecast $q$ quarters ahead and the realized interest rate during that quarter:

$$RMSE_{IRP,j,q} = \sqrt{\frac{(i_{t+q} - E[i_{t+q}])^2}{n}}$$

(2)

where $IRP$ refers to the RMSE of interest rate projections, $j$ corresponds to either the Norges Bank (NB) or the Riksbank (R) and the $q$-quarter ahead forecast is being evaluated. The number of observations for the $q$-period ahead projections is represented by $n$. The quarter in which the report is published is considered time $t$. Table 1 details the publication dates of each report by the Norges Bank containing interest rate projections, as well as the quarter in which the report was released. Since only three $Reports$ are released per year,
some quarters are not covered by all of the \( q \)-period-ahead projections.

RMSEs of interest rate projections are calculated for one-, two-, three- and four-quarter-ahead interest rate projections for two sets of data: 1) the entire sample, and 2) projections realized prior to the third quarter of 2008. The financial crisis caused large changes in the interest rate paths of both the Norges Bank and Riksbank. While these large errors should not be ignored because of the questions they raise about the value of publishing projections in the face of uncertainty, examining the entire sample and the subsample allows one to determine if a disproportionate amount of error is a result of several observations with large errors. The RMSEs of interest rate projections are also calculated separately using only Reports and using the latest publication in a quarter. The second method includes Monetary Policy Updates (MPUs), abbreviated reports that contain new projections. This means that with the second method, the Norges Bank’s MPU December 2008 is used instead of MPR 3/2008. However, this update was a strategic release in response to changing economic conditions that rendered prior projections moot.

The results of the measures of the Norges Bank’s RMSEs of interest rate projections can be found in Table 2. The units of RMSEs are percentage points, making them directly comparable to the interest rates that they are evaluating; they are analogous to standard errors. In general, the Norges Bank is more accurate for shorter projections, an unsurprising result. One notable exception to this is the one-quarter-ahead RMSE of the entire sample using only reports, which at 0.4297 is higher than the two-quarter-ahead projection. However, since projections are only published three times a year, one-quarter-ahead projections are not available for the fourth quarter of 2008, while two-quarter-ahead projections are not available for the first quarter of 2009. Projections from both these quarters are available for three- and four-quarter-ahead projections. The larger one-quarter-ahead projections can be attributed to the differences in available quarters. The performance of the Norges Bank’s one-period-ahead projections also improves when using its December Update rather than MPR 3/2008, as this incorporated declining interest rate projections not contained in pre-
vious forecasts. Projections of more than one quarter into the future have not changed by using the Update because actual values have yet to be realized.

As one would expect, excluding projections realized after the third quarter of 2008, the projections most influenced by the financial crisis, reduces the RMSE of the Norges Bank interest rate projections. As the charts from the Norges Bank reports show (Figure 4), the negative effect of the financial crisis on the Norwegian economy and the need of the Norges Bank to cut interest rates were not predicted in MPR 3/2007. Even in MPR 3/2008, the realized sight deposit rate in the first quarter of 2009 fell outside of the ninety percent confidence interval from a report issued five months prior.

During times of less uncertainty, the Norges Bank’s projections seem to perform reasonably well; however, the projections did not predict the magnitude of the decline in interest rates as a result of the crisis, even as late as the third quarter of 2008. While it would be unrealistic to expect the Norges Bank to only need to make minor changes to its projections in every period, when realized rates fall outside of ninety percent bands, questions about the benefits of publishing rates arise.

### 3.3 Riksbank

#### 3.3.1 Background and Reports

The Riksbank began operating with an inflation target of 2 percent (with a “tolerance band” of one percent) in 1995 and began publishing interest rate projections in February 2007. Similarly to the Norges Bank, the Riksbank is a flexible inflation-targeting central bank (Svensson 2008b); the Riksbank seeks to conduct “well-balanced monetary policy,” meaning “inflation is close to the inflation target two years ahead without there being excessive fluctuations in inflation and the real economy” (Riksbank MPR February 2009, p. 4). This quote shows that the Riksbank has a clearly defined time horizon by which it hopes to stabilize inflation at its target level instead of the vaguer “medium term” horizon used by the Norges Bank.
Like the Norges Bank, the Riksbank’s MPC is known as the Executive Board. The Executive Board is made up of 6 members, with one appointed as the Governor. All members are selected by the General Council of the Riksbank, a group appointed by the Swedish Parliament to oversee the banks operation (Sveriges Riksbank “The Executive Board”). In the past, The Executive Board generally met seven times a year, but currently its guidelines suggest six meetings a year to set its key policy interest rate, the repo rate (Sveriges Riksbank “Separate appendix”). The repo rate is the interest rate paid on one-week repurchase agreements between the Riksbank and market participants and represents the Riksbank’s desired overnight lending rate. The repo rate is also directly tied to the deposit rate, the rate at which the Riksbank pays interest on overnight deposits, and the lending rate, the rate at which banks can borrow funds overnight from the Riksbank. The deposit and lending rates are set at 0.75 percentage points above and below the repo rate, respectively, forming a ceiling and floor for the overnight interest rate. The Riksbank also intervenes with “fine-tuning operations,” where the Riksbank meets either additional borrowing or lending demand at an interest rate 0.1 percentage points above or below the repo rate to help avoid large daily fluctuations (Sveriges Riksbank “The Riksbank’s Management of Interest Rates,” pp. 12-13).

Currently, the Riksbank publishes its Monetary Policy Report after the Riksbank’s monetary policy meetings in February, June or July and October. Like the Norges Bank, these were called Inflation Reports until 2007. These reports offer substantial insights into projected monetary policy, the condition of the economy and the main areas of uncertainty for future developments in the economy. Additionally, the Riksbank now publishes Monetary Policy Updates after its other three meetings, while the Norges Bank does not, with the exception of December 2008. The Riksbank’s updates are not as detailed as the reports, focusing mainly on the reasons behind the repo rate decision, but the updates do provide new projections of the repo rate, inflation rate and GDP growth rate. The Riksbank also made a systematic decision to publish MPUs, in contrast to the Norges Bank’s decision to
strategically publish in response to changing economic conditions.

Figure 5 presents projections from the Riksbank’s first report for 2009, *MPR February 2009*. Recently, monetary policy has been eased in response to falling GDP growth and inflation. An approximate relationship among the interest rate, GDP and inflation can be seen through the projections, like with the Norges Bank. Falling GDP and inflation correlates with falling interest rates in an attempt to stimulate additional growth and to prevent inflation from falling below the tolerance interval. As inflation and GDP recover, the monetary policy accommodation is removed by raising interest rates. By including projections of both the repo rate and target variables, the private sector can better understand the central bank’s view of the economy and potentially use this to help predict how new developments in target variables will influence the repo rate.

The Riksbank also describes multiple alternative scenarios that would lead to different paths for the repo rate and target variables. Two of the alternative scenarios explained in *MPR February 2009* describe uncertainty related to the duration and severity of the financial crisis. The report notes that it is possible the crisis could be more pervasive than expected, but recovery could also come more rapidly if the measures to combat the crisis taken by countries around the world lead to an increase in global demand. Therefore, the Riksbank presents figures on the development of the repo rate and selected variables under these conditions (Figure 6 presents the repo rate, GDP and CPI projections, but *MPR February 2009* also contains measures such as GDP abroad and production and labor gaps.)

Like the Norges Bank, the Riksbank has also used *MPRs* to communicate its views of the economy to the public. Both central banks exhibit a greater degree of openness than many other central banks through their willingness to provide quantitative projections to markets. However, in order for this openness to benefit the public, it must provide valuable information to the public.
3.3.2 Performance of Projections

The Riksbank’s interest rate projections had trouble predicting the falling rates in late 2008 and early 2009, but the baseline estimates were comparable to realized interest rates for the first few quarters after each report. Figure 7 contains fan charts from the first and third MPR of 2007 and 2008, with the realized interest rate superimposed. The solid red line represents the actual repo rate through the time the report was published, and the dotted red line is the baseline projection of the report. The solid black line represents the realized interest rate for quarters after the release of the MPR, and the fan charts represent confidence intervals, with the bands from lightest to darkest representing fifty, seventy and ninety percent intervals.

Like the Norges Bank, the Riksbank also overestimated the repo rate for late 2008 and early 2009 in its third MPR of 2008; the realized rate fell slightly (one basis point) outside of the ninety percent confidence interval for the fourth quarter of 2008 and well outside of the ninety percent confidence interval by the first quarter of 2009. Additionally, the range from the upper ninety percent to lower ninety percent bounds is larger in this report than in all others. In the other projections pictured in Figure 7, this range achieves its maximum in MPR 2007:1 at 3.62 percentage points, while the range rose to 5.71 percentage points in MPR 2008:3. However, even incorporating a larger range at the horizon did not help the Riksbank forecasts predict the magnitude of short-term decreases in interest rates.

The RMSEs of the interest rate projections were calculated in the same manner as those of the Norges Bank, with a few slight differences. First, since the Riksbank began releasing Monetary Policy Updates after each meeting beginning in December 2008, there is more of a difference between the “Reports Only” and “Latest Publication” measures. Including MPU also increases the number of quarters covered by projections. Second, the Riksbank’s second report of 2008 was released on July 3, 2008, which is technically in the third quarter of 2008. However, I have classified this report as being released in the second quarter of 2008 for comparability purposes. All the other second reports of the year by the Norges Bank and
Riksbank were released in the second quarter. Due to the proximity of the release date of MPR 2008:2 to the end of the second quarter, the vast majority, if not all, of the information used to develop the projections contained in this report is from the second quarter of 2008. Therefore, MPR 2008:2 better represents projections from the second quarter of 2008. Table 3 presents publication dates for MPRs and MPU$s released by the Riksbank that contain interest rate projections.

The RMSEs of the Riksbank’s interest rate projections exhibit hints of the general pattern observed with the Norges Bank of increasing as the projection horizon increases (see Table 4). The smaller sample size compared to the Norges Bank magnifies the effect of large errors even more, and discrepancies due to missing quarters as a result of thrice-yearly reports can also be larger. Excluding observations after the third quarter of 2008, the Riksbank outperformed the Norges Bank on one- and two-quarter-ahead projections. However, the Norges Bank’s RMSEs were lower across the entire sample, especially at horizons of three and four quarters. This could be due to superior forecasting or less variability across the entire sample. Since the Riksbank did not begin publishing until 2007, a larger proportion of their projections occurred during the uncertainty surrounding the global financial crisis. This could explain some of the differences between the RMSEs of the Norges Bank and Riksbank. The RMSEs of the three- and four-quarter-ahead projections of the entire sample for the Riksbank are substantial; 1.48 percentage points for four-quarter-ahead projections means large shifts and adjustments are occurring over the course of the projection.

This shows that the problem of large projection errors was not endemic specifically to the Norges Bank; rather, both the Norges Bank and Riksbank were surprised by the effect of the crisis. The performance of both central banks raise the questions about the usefulness of publishing projections, especially in times of greater economic uncertainty.
4 The Model

4.1 Framework

This paper uses a New Keynesian macroeconomic model common in the literature and based on Woodford (2003) to examine the theoretical effect of publishing interest rate projections. The IS curve is represented by:

\[ x_t = E_t x_{t+1} - \sigma [i_t - E_t \pi_{t+1}] + g_t, \]

where \( x_t \) is the output gap, as defined in Equation 1; \( i_t \) is the nominal interest rate; \( g_t \sim N(0, \sigma_g^2) \) is an i.i.d. exogenous shock; \( \pi_t \) is the inflation rate; and \( E_t \) denotes the expectation for a variable taken at time \( t \). Inflation is defined by the New Keynesian Phillips curve:

\[ \pi_t = \kappa x_t + \beta E_t \pi_{t+1} + u_t, \]

where \( u_t \sim N(0, \sigma_u^2) \) is an i.i.d. exogenous cost-push shock. \( \beta, \kappa \) and \( \sigma \) are parameters of the model representing the discount rate, inflation’s sensitivity to the output gap and the intertemporal elasticity of substitution, respectively. The exogenous shocks \( u_t \) and \( g_t \) are assumed to be serially uncorrelated, one-period shocks.

In this model the central bank is assumed to be a flexible inflation-targeter; therefore, the central bank seeks to keep inflation close to its target as a primary goal while also keeping output as close to its potential as possible. The central bank conducts monetary policy by setting the interest rate \( i_t \) in each period in a way that minimizes the loss function (Equation (1)) across all periods. Woodford (2003) proves that the following first-order condition must
be satisfied for monetary policy to be optimal from the timeless perspective:  \(^2\)

\[
(\pi_t - \pi^*) + \frac{\lambda}{\kappa} (x_t - x_{t-1}) = 0. \tag{5}
\]

With equations (3), (4) and the condition in (5), this yields a model with three equations and three unknowns. I now solve the model in terms of the output gap and inflation target, then use these to find the optimal interest rate reaction function.

### 4.2 Solving the Model

Equation (5) can be transformed to give an equation for inflation in terms of the inflation target and the change in the output gap from the previous period:

\[
\pi_t = \pi^* - \frac{\lambda}{\kappa} (x_t - x_{t-1}). \tag{6}
\]

This equation can then be used to find the expected one-period-ahead inflation rate:

\[
E_t \pi_{t+1} = \pi^* - \frac{\lambda}{\kappa} (E_t x_{t+1} - x_t). \tag{7}
\]

Substituting (6) and (7) into (4) yields an equation in terms of the output gap:

\[
\beta E_t x_{t+1} - \left(1 + \beta + \frac{\kappa^2}{\lambda}\right) x_t + x_{t-1} = \left(\frac{\kappa}{\lambda}\right) + \pi^* \frac{\kappa}{\lambda} (\beta - 1). \tag{8}
\]

This can be solved through the method of undetermined coefficients. Let:

\[
x_t = b_x x_{t-1} + c_x u_t \tag{9}
\]

\[
\pi_t = \pi^* + b_\pi x_{t-1} + c_\pi u_t, \tag{10}
\]

\(^2\)This stems from Woodford (2003) Equation (5.1) in Chapter 7 (p. 523). I have modified it to include a non-zero inflation target \(\pi^*\).
similar to Evans and Honkapohja (2006) but incorporating \( \pi^* \), the inflation target. With rational expectations, (8) has a characteristic equation of the form:

\[
\beta b_x^2 - \left( 1 + \beta + \frac{\kappa^2}{\lambda} \right) b_x + 1 = 0.
\]

(11)

Defining \( \gamma = \left( 1 + \beta + \frac{\kappa^2}{\lambda} \right) \), solving (11) for \( b_x \) yields:

\[
\bar{b}_x = \frac{\gamma \pm \sqrt{\gamma^2 - 4\beta}}{2\beta}.
\]

If \( \bar{b}_x > 1 \), \( x_t \) will be explosive, and the output gap will continue to increase in each subsequent period. In order for (9) to be non-explosive, \( 0 < \bar{b}_x < 1 \), so

\[
\bar{b}_x = \frac{\gamma - \sqrt{\gamma^2 - 4\beta}}{2\beta}
\]

is the solution of interest. Solving for the other undetermined coefficients gives:

\[
\bar{c}_x = \frac{-1}{\kappa + \beta \pi_x + \frac{\lambda}{\kappa}}
\]

(12)

\[
\bar{b}_\pi = \frac{\lambda}{\kappa} (1 - \bar{b}_x)
\]

(13)

\[
\bar{c}_\pi = -\frac{\lambda}{\kappa} \bar{c}_x.
\]

(14)

Therefore,

\[
x_t = \left\lfloor \frac{\gamma - \sqrt{\gamma^2 - 4\beta}}{2\beta} \right\rfloor x_{t-1} + \left[ \frac{-1}{\kappa + \frac{\lambda}{\kappa} \left( 1 + \beta - \left( \frac{\gamma - \sqrt{\gamma^2 - 4\beta}}{2\beta} \right) \right)} \right] u_t
\]

(15)

\[
\pi_t = \pi^* + \left[ \frac{\lambda}{\kappa} \left( 1 - \left( \frac{\gamma - \sqrt{\gamma^2 - 4\beta}}{2\beta} \right) \right) \right] x_{t-1} + \left[ \frac{\lambda}{\kappa^2 + \lambda \left( \frac{\gamma - \sqrt{\gamma^2 - 4\beta}}{2\beta} \right)} \right] u_t.
\]

(16)
With $x_t$ and $\pi_t$, one can solve for $i_t$, the interest rate reaction function. To keep the notation simpler, the coefficients $\bar{b}_x, \bar{c}_x, \bar{b}_\pi$ and $\bar{c}_\pi$ are used rather than the parameters that make up their solutions. Solving the IS equation (3) for $i_t$ yields:

$$i_t = \sigma^{-1} [E_t x_{t+1} - x_t + \sigma E_t \pi_{t+1} + g_t]. \quad (17)$$

The $t$-period expectations of $x_{t+1}$ and $\pi_{t+1}$ obtained from (9) and (10) are:

$$E_t x_{t+1} = \bar{b}_x^2 x_{t-1} + \bar{b}_x \bar{c}_x u_t \quad (18)$$

$$E_t \pi_{t+1} = \pi^* + \bar{b}_\pi \bar{b}_x x_{t-1} + \bar{b}_\pi \bar{c}_x u_t. \quad (19)$$

Substituting these equations into (17) results in the reaction function for this model:

$$i_t = \pi^* + \phi_x x_{t-1} + \phi_u u_t + \phi_g g_t, \quad (20)$$

where

$$\phi_x = \bar{b}_x [\sigma^{-1} (\bar{b}_x - 1) + \bar{b}_\pi]$$

$$\phi_u = \bar{c}_x [\sigma^{-1} (\bar{b}_x - 1) + \bar{b}_\pi]$$

$$\phi_g = \sigma^{-1}.$$

With this model solved, it is possible to use it to determine the potential effects of publishing interest rate projections. At time $t$, the central bank sets $i_t$ based on last period’s output gap $x_{t-1}$ and the current shocks $u_t$ and $g_t$. It also determines its expected value for the interest rate in the next period, $E_{t,CB}i_{t+1}$, where

$$E_{t,CB}i_{t+1} = \pi^* + \phi_x x_t, \quad (21)$$
since $E_t u_{t+1} = 0$ and $E_t g_{t+1} = 0$. The central bank then communicates its expected interest rate to the public but with transmission noise, similar to Rudebusch and Williams (2006). The transmission noise $z$ is a mean zero i.i.d. shock where its variance $\sigma_z^2$ depends upon the communication strategy employed by the central bank. The clearer the central bank’s communication strategy, the lower $\sigma_z^2$. The private sector thus sets the interest rate one period into the future as:

$$E_{t,\text{Market}}^t i_{t+1} = E_{t,\text{CB}}^t i_{t+1} + z,$$

where $z \sim N(0, \sigma_z^2)$. Once the central bank sets the interest rate in period $t + 1$, the private sector then adjusts to the realized interest rate.

This model assumes that the central bank projections are at least as good as those by the private sector. This allows the central bank to be credible and avoids the problem of suboptimal coordination described in Morris and Shin (2002). It also requires that the central bank and private sector can perfectly determine the magnitude of the shocks in real time. In reality, forecasting in real time is a challenge, evidenced by ex-post revisions of many macroeconomic variables of interest.

### 4.3 Testable Implications

To address whether or not publishing interest rate projections are beneficial, one must define outcomes that would be considered desirable results of the publication of interest rate projections. The outcomes must also be empirically testable and enlightened by the theoretical model.

One desirable outcome of the publication of projections would be a decline in the root mean square error of the market’s expectations for interest rates. In this model, a decline in the RMSE of market expectations for interest rates would indicate that publications by the central bank have helped better align market expectations for the one-period-ahead interest rate. If the private sector has a better idea of the future cost of lending, it could be better
able to make intertemporal decisions that maximize welfare due to its understanding of future rates.

Calculating the RMSE of market expectations for future interest rates from the model yields:

\[
RMSE = \sqrt{E \left[ (i_{t+1} - E_{t,\text{Market}}i_{t+1})^2 \right]} \\
= \sqrt{E \left[ (\phi_u u_{t+1} + \phi_g g_{t+1} - z_t)^2 \right]} \\
= \sqrt{\phi_u^2 \sigma_u^2 + \phi_g^2 \sigma_g^2 + \sigma_z^2}.
\]

This result implies that increased transmission noise leads to greater errors in the private sector’s prediction of the central bank’s future interest rate. Proponents of publishing interest rate projections would argue that publication does indeed reduce the transmission noise because it offers quantitative numbers and data on which the markets can form their expectations. For example, the Norges Bank’s projections offer much more specific information about their projected future policy intentions than the bias statements of the Federal Reserve, which instead only hint at actions that might be taken. Proponents of publishing projections would say that this implies that:

\[
\sigma_z^2,\text{Publishing} < \sigma_z^2,\text{Non-publishing},
\]

which in turn means:

\[
RMSE_{\text{Publishing}} < RMSE_{\text{Non-publishing}}.
\]

If this is true, publishing projections makes the central bank more predictable, helping the private sector better forecast future interest rate developments. Rudebusch and Williams (2006) assumed that transmission noise would decrease as transparency increased and therefore assumed that publishing interest rate projections would reduce transmission noise. However, as discussed in the Section 2.2, some critics may disagree that publishing reduces
transmission noise because publishing could distract the public.

One can attempt to examine the relationship between $\sigma^2_{z,Publishing}$ and $\sigma^2_{z,Non-publishing}$ empirically by comparing the RMSE before and after the publication of interest rate projections. As (23) shows, the RMSE in expectation will be influenced by the model’s parameters, the variances of exogenous shocks $u_t$ and $g_t$ and the variance of the transmission noise. Assuming the parameter values and shock variances are constant over time, in large samples differences in the RMSE before and after publishing an interest rate projection should be due to a change in the variance of the transmission noise $\sigma^2_z$. Since the Norges Bank and Riksbank began publishing interest rate projections recently, estimates of the sample RMSE may be biased by shocks in either the before or after period that were not offset in the other period, making inference more difficult.

I calculate the RMSE of market expectations by comparing the quarterly average of overnight money market rates to the quarterly average of forward rates one, two, three and four quarters into the future. In the case of Norway, I use daily observations of the Norwegian Interbank Offered Rate (NIBOR) to calculate forward rates, while I use the Stockholm Interbank Offered Rate (STIBOR) for Sweden. The effective annual rate (EAR) of daily forward rates is calculated, then averaged over the quarter to form the quarterly expectation for future overnight money market rates. Effective annual forward rates are calculated as follows:

$$E_{t,Money\Market}i_{t+q} = \frac{(1 + i_q)^q}{(1 + i_{q-1})^{q-1}} - 1,$$

where $q = 1, 2, 3, 4$, representing the number of quarters ahead the forward rate estimates; and $i_q$ signifies the $q$-quarter-ahead money market rate, which corresponds to three, six, nine and twelve month money market rates, respectively. These forward rates are calculated for each daily observation then averaged to find the quarterly rates from which the RMSE of market expectations of money market rates is found.

I also examine the magnitude of changes in rates in response to interest rate decisions. I calculate the absolute change in market interest rates after the interest rate announce-
ment, then find the mean daily absolute change. If interest rates are more predictable after publishing interest rate projections, the mean daily absolute changes should be lower after publishing began. This can provide a robustness check for the RMSE of market expectations results.

5 Empirical Results

5.1 Norges Bank Results

The theoretical model implies that if publishing interest rate projections reduces transmission noise, it should lead to a decline in the RMSEs of market expectations of interest rates. The RMSE of market expectations compares the RMSE of the average quarterly NIBOR next-day effective rate to the NIBOR three-month effective rate and three-to six-month, six- to nine-month and nine- to twelve-month forward rates calculated from NIBOR effective rates. The RMSE of the three-month NIBOR rate to the overnight rate is denoted as the one-quarter-ahead plotted values, the three- to six-month forward rate corresponds to two-quarter-ahead plotted values, and so forth. The quarter denotes the quarter in which the market expectations were made.

Figure 8 presents the RMSEs of market expectations from the first quarter of 1991 and the second quarter of 2001 to the first quarter of 2009, respectively. The date range of Figure 8.a corresponds to results since the Norges Bank began paying interest on sight deposits, and this rate became the key policy rate in mid-1993 (Norges Bank “Norges Bank’s Key Policy Rate”). The range of Figure 8.b covers the period since the Norges Bank began inflation targeting. The spikes in RMSEs occur during times of large changes in the sight deposit rate and are greater in times of declining rates (see Figure 9). This interesting observation could be explained by the fact that rates seem to be cut faster than they are raised or because cutting interest rates is generally associated with slowing economic growth and recessions. The Norges Bank may move more rapidly or aggressively in recessions than during periods
of growth, therefore producing greater uncertainty about future interest rate changes as well as changes of larger magnitudes that would make predicting future interest rates more challenging in times of recessions.

The Norges Bank began publishing interest rate projections in November 2005, but the RMSE of market expectations for interest rates declined and remained low prior to this date. The RMSEs for all horizons remained below half a percentage point from the second quarter of 2004 until the third quarter of 2005, after which point they increased slightly. Since the RMSEs were low before the Norges Bank began publishing projections, it suggests that factors other than publishing contributed to the predictability of money market interest rates during this time period. The low RMSEs occur over a period when the sight deposit rate remained unchanged and resemble RMSEs from late 2000 to late 2001, the last time the sight deposit was held constant for an extended period of time. The peak of two-, three- and four-quarter-ahead RMSEs from 2006 to 2007, a period of steadily increasing sight deposit rates while the Norges Bank published projections, fell below the peak of the last set of steady interest rate increases in 2000. However, the Norges Bank was not an inflation-targeting central bank in 2000, so the private sector had less information about the goals of the Norges Bank in 2000 even if the Norges Bank had not begun publishing projections in November 2005. Transmission noise may have declined due to the implementation of an inflation target rather than as a result of publishing projections, which would have also led to these differences between the two periods.

In order to determine if the mean RMSE is different in periods before and after publishing interest rate projections, I use several comparison groups. First, I compare the period under inflation targeting but prior to the publishing of interest rate projections (Q2 2001 to Q3 2005, the “before publishing” period) to the period with published projections (Q4 2005 to Q1 2009, the “after publishing” period). I then compare the fourth quarter of 2003 through the third quarter of 2005 to the fourth quarter 2005 through the third quarter of 2007 (the “Alternate Sample”), which avoids forecasts covering the two large declines in the sight
deposit rate since the Norges Bank began inflation targeting. I conduct t-tests for differences in means with equal or unequal variances, depending on the results of F-tests for differences in variances. Table 5 presents p-values for the null hypothesis that the means in both periods are equal, as well as for the alternate hypothesis that the mean is lower after publishing. When using the entire sample, I find no statistically significant difference in means before and after publishing projections. In the alternate sample, the means are different but lower prior to publishing projections. While the period before publishing projections contained the period of constant interest rates, this underscores the point that money market interest rates were quite predictable prior to publishing projections.

One could also measure interest rate predictability by the amount market interest rates change in response to interest rate decisions by the MPC of a central bank. If the private sector is able to anticipate interest rate decisions, then there should be little movement in interest rates from before the announcement of the interest rate decision to after the announcement. Conversely, large adjustments in market interest rates indicate that the private sector was not able to predict the interest rate decision. This is similar to the analysis in Holmsen, et al. (2008), which looked at mean daily absolute changes in Norwegian money market rates in response to interest rate decisions from the beginning of inflation targeting in April 2001 to October 2008. I update their results through the Norges Bank MPC meeting on March 25, 2009. I look at NIBOR rates for maturities of one week to twelve months. In addition to changes in money market rates, I also calculate changes when including interest rates on three-year government bonds. Three-year bonds would mature within the horizon of the Norges Bank’s projections and could therefore be expected to adjust when new projections are released.

The Norges Bank updates NIBOR rates at 12:00 P.M. daily, and the Norges Bank’s Executive Board announces interest rate decisions at 2 P.M. on the day of their meeting. I calculate the absolute change in interest rates from 12 P.M. the day of the meeting to 12 P.M. the following business day. These changes are depicted in Figure 10. I conduct t-tests
for differences in the means of the mean absolute daily change before and after the Norges Bank began publishing in the period under inflation targeting. I also conduct t-tests on the absolute changes adjusted for the median absolute daily change in each period, as done in Holmsen, et al. (2008), to control for potential changes in volatility between the two periods not due to publishing projections. The median absolute change in each period is subtracted from each mean daily absolute change. The large mean daily absolute change in October 2008 can be attributed to an additional, previously unscheduled interest rate meeting in response to the financial crisis. Table 6 contains p-values for the null hypothesis that the means are equal in both periods and the alternative hypothesis that the mean is lower after publishing. “NIBOR” refers to mean daily absolute changes using NIBOR interest rates, while “Range” refers to the NIBOR rates and the three-year government bond rate that falls within the range of the horizon of the Norges Bank’s projections. The means were not statistically significantly different in terms of absolute changes or adjusted changes.

5.2 Riksbank Results

Similarly to the Norges Bank, the ability of markets to predict future interest rates seems to have improved prior to the publication of interest rate projections. Figure 11.a presents the RMSE of market expectations beginning in July 1998, when the Riksbank began tracking the STIBOR next-day rate. Figure 11.b depicts the Swedish results over the time period since the Norges Bank began inflation targeting for comparability. The Riksbank began publishing projections in February 2007 while RMSEs remained below 0.5 percentage points from April 2005 to July 2007. The repo rate remained constant or increased during this time period (Figure 12). The RMSEs of the Riksbank are lower on the whole than those of the Norges Bank, with all RMSEs prior to 2008 under two percentage points. However, this means the errors associated with the financial crisis in 2008 and 2009 are proportionally much larger. The magnitude and speed with which the Riksbank cut the repo rate in response to the financial crisis was much larger and faster than the incremental cuts in previous periods
of rate declines. It is also interesting to note that the Riksbank held the repo rate in a tighter band than the Norges Bank. The range of rates set by the Riksbank from 1998 to the end of the first quarter of 2009 varied from a low of one percent to a high of 4.35 percent, while the sight deposit rate of the Norges Bank fluctuated between 1.75 and eight percent over the same period.

I conduct t-tests for differences in means of RMSEs of market expectations before and after publishing for the period matching the Norges Bank’s time with inflation targeting. There is no statistically significant difference in the mean RMSE between the two periods (Table 7). Since the Riksbank has only been publishing projections since 2007, a greater proportion of the projections were influenced by the large errors associated with the financial crisis. Constructing an alternate sample excluding projections realized during the interest rates decline of late 2008 and early 2009 would not leave sufficient observations for meaningful results.

The private sector has generally been able to predict the Riksbank’s interest rate decisions until late 2008 (Figure 13). The Riksbank announces interest rate decisions in a press release at 9:30 A.M. the morning after MPC meetings. STIBOR rates are calculated at 11:05 A.M., so I consider the absolute change in interest rates from 11:05 A.M. the business day prior to the press release to 11:05 AM the business day following the press release in order to give money market rates sufficient time to adjust. I compare the Riksbank’s interest rate decisions over the same time period as those used in Norway, from April 2001 to March 2009. I use STIBOR rates for maturities of one week to twelve months and include changes on two-year government bonds when examining changes for rates that fall within the range of the Riksbank’s interest rate projections. Adjustments for the median absolute change in the period prior to publishing projections, April 2001 to January 2007, and the post-publishing period, February 2007 to March 2009, are also calculated. The large change in October 2008 was due to a cut in the repo rate in concert with central banks from around the world to combat the financial crisis. Table 8 contains the p-values of t-tests for the null hypothesis
that the means in both periods are equal and the alternate hypothesis that the mean is lower after publishing. The p-values suggest that the mean change was lower prior to publishing projections, but this is somewhat tempered when the absolute changes are adjusted by the median change over the period.

5.3 Discussion

Although it is difficult to draw concrete conclusions from the limited amount of empirical data available at this time, these results do raise some important questions about the publication of interest rate projections. Publishing projections does increase transparency and provides the private sector with more information about anticipated future actions by the central bank, but publishing projections does not appear to be a necessary prerequisite for the private sector to be able to predict future money market interest rates. The periods of low RMSEs of market expectations prior to publishing projections suggest that in these periods, communication by the Norges Bank and Riksbank adequately provided the private sector the information needed to accurately set money market rates for maturities of three to twelve months. If transmission noise was already low before publishing projections, the gains associated with further reducing the transmission noise could be small, similar to the “crowding out” noted by Dale, Orphanides and Österholm (2008). One could envision the benefits of reducing transmission noise as being subject to diminishing marginal returns. Since publishing projections is advisable when the benefits are larger than the costs, the potential for small gains implies that potential costs, such as a loss of credibility or public distraction, must be even smaller.

Ideally, one would be able to compare the RMSEs of market expectations and absolute value of changes in response to interest rate announcements under the same economic conditions but without the central bank publishing interest rate projections. Since this counterfactual is not available, there will be questions about whether the improvement in market expectations was lost among the large shocks affecting the global economy from the
financial crisis. It is possible that the private sector’s expectations would have performed worse if it were not for the interest rate projections. However, convincingly justifying the fact that private sector expectations would have been worse is made challenging due to the large errors associated with interest rate projections by both the Norges Bank and Riksbank during the financial crisis.

Some of the benefits of publishing interest rate projections may be harder to quantify. Holmsen, et al. (2008) noted a different sort of positive effect of publishing interest rate projections for central banks. Using an endogenous interest rate emphasizes the role a wide variety of economic indicators and inputs play in the interest rate decision. The staff of the central bank, along with its MPC, must decide which of these variables should be included and how much weight they should carry for interest rate decisions. Additionally, the central bank provides another way for the public to evaluate its performance by publishing projections. Perhaps this increased accountability will force economists at the central bank to think harder about the models and assumptions that are used to conduct monetary policy. This could lead to greater accuracy in forecasting and better macroeconomic models.

6 Conclusion

This paper has examined the practice of publishing interest rate projections by the Norges Bank and Riksbank in hopes of providing insight into key questions in the debate about publishing these projections. While it is still early to draw definitive conclusions about the effect of publishing interest rate projections, this paper does offer some key insights to arguments on both sides of the debate over publishing projections.

Both the Norges Bank and Riksbank have been able to agree on interest rate paths with MPCs. Anecdotal evidence from Svensson (2008b) indicates that reaching an agreement has not been an issue for the Riksbank, although the institutional framework will play a role in determining how easily publication could be adopted. This seems to suggest that
concerns about the challenges of publishing interest rate projections for a MPC should not be generalized to a concern about the practice of publishing interest rate projections; rather, these concerns should be addressed on a case-by-case basis for central banks contemplating publishing projections. The members of the central bank’s own MPC should have the best idea about the feasibility of reaching an agreement on an interest rate path.

The evidence of my paper does seem to point against either of these two central banks feeling constrained by their projections. Both the Norges Bank and Riksbank have demonstrated a willingness to set interest rates outside of their ninety percent confidence intervals, sometimes just quarters after projections were made. This should ease concerns of critics who worried central banks would be tempted to stick to their projections in order to maintain credibility. However, it does not address whether or not these substantial deviations have affected the credibility of the Norges Bank and Riksbank. Proponents would hope the banks have made the conditionality of their projections clear enough to avoid losing credibility because of errors in their projections. The additional accountability that comes with presenting the markets with the level of detail in the projections of the Norges Bank and Riksbank should offer the banks an incentive to improve their forecasting ability. Nonetheless, changes of this magnitude raise questions about the amount of useful information contained in the interest rate projections.

The empirical evidence suggests that the effect of publishing interest rate projections on the private sector’s ability to predict future interest rates may be small. The Norges Bank and Riksbank are two of the most transparent central banks in the world, and it appears that interest rates were already relatively predictable prior to publishing interest rate projections. Both central banks also struggled to create viable projections in the midst of the uncertainty surrounding the financial crisis. If the gains of publishing interest rate projections are small, the costs must be even smaller in order to justify undertaking publishing.
7 Appendix: Tables and Figures

Figure 1: Projections from Norges Bank Monetary Policy Report 1/2009. Figures taken from report. The solid black line represents realized results, the dotted black line represents forecasts for the baseline scenario, and the fan charts represent confidence intervals. The bands, moving from darkest to lightest, correspond to 30 percent, 50 percent, 70 percent and 90 percent confidence intervals.
Figure 2: Projections from Norges Bank *Monetary Policy Report 1/2009* in baseline and alternative scenarios. Figures taken from report. The solid black line represents realized results, the dotted black line represents forecasts for the baseline scenario, and the fan charts represent confidence intervals. The bands, moving from darkest to lightest, correspond to 30 percent, 50 percent, 70 percent and 90 percent confidence intervals. The dotted red line represents a scenario with lower-than-expected demand and the dotted yellow line represents higher-than-expected demand.
Figure 3: Norges Bank “Interest Rate Account” from *MPR 1/2009*. Percentage points. Figure taken from the report. The bars represent the amount of change in the interest rate projection from the previous report attributed to each factor. The black line represents the change in the interest rate path from the baseline scenario of the previous report to the baseline scenario in the current report.

<table>
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<tr>
<th>Report/Update</th>
<th>Publication Date</th>
<th>Quarter of Publication</th>
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<td>IR 3/2005</td>
<td>11/2/05</td>
<td>Q4 2005</td>
</tr>
<tr>
<td>IR 1/2006</td>
<td>3/16/06</td>
<td>Q1 2006</td>
</tr>
<tr>
<td>IR 2/2006</td>
<td>6/29/06</td>
<td>Q2 2006</td>
</tr>
<tr>
<td>IR 3/2006</td>
<td>11/1/06</td>
<td>Q4 2006</td>
</tr>
<tr>
<td>MPR 1/2007</td>
<td>3/15/07</td>
<td>Q1 2007</td>
</tr>
<tr>
<td>MPR 3/2007</td>
<td>10/31/07</td>
<td>Q4 2007</td>
</tr>
<tr>
<td>MPR 1/2008</td>
<td>3/13/08</td>
<td>Q1 2008</td>
</tr>
<tr>
<td>MPR 2/2008</td>
<td>6/25/08</td>
<td>Q2 2008</td>
</tr>
<tr>
<td>MPR 3/2008</td>
<td>10/29/08</td>
<td>Q4 2008</td>
</tr>
<tr>
<td>MPU Dec. 2008</td>
<td>12/17/08</td>
<td>Q4 2008</td>
</tr>
<tr>
<td>MPR 1/2009</td>
<td>3/25/09</td>
<td>Q1 2009</td>
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Table 1: Publication dates and their corresponding quarter for *Inflation Reports (IRs)*, *Monetary Policy Reports (MPRs)* and *Monetary Policy Updates (MPUs)* of the Norges Bank that included interest rate projections. The number prior to the backslash in the report title represents the number of the report released in the given year. The quarter classification is used for the quarter $t$ in RMSE calculations.
Figure 4: Projections from Norges Bank’s third *Inflation Report* and *Monetary Policy Report* of the year, 2005 to 2008. The projections were taken from charts released by Norges Bank in connection with their reports. The solid black line represents actual results up to the release date of the report, the dotted black line represents forecasts for the baseline scenario and the fan charts represent confidence intervals. The bands, moving from darkest to lightest, correspond to 30 percent, 50 percent, 70 percent and 90 percent confidence intervals. The red line was added by the author and represents the realized sight deposit rate from the publication of the report until Q1 2009.
Figure 5: Projections from the Riksbank’s first report of 2009, *MPR February 2009*. Figures taken from report. The solid red line represents realized results, the dotted red line represents projections in the baseline scenario and the fan charts represent uncertainty bands calculated using historical forecast errors. The bands, moving from lightest to darkest, represent 50, 75 and 90 percent confidence intervals.
Figure 6: Projections from the Riksbank’s *MPR February 2009* in baseline and alternative scenarios. Figures taken from the report. The solid red line represents realized results, the dotted red line represents projections in the baseline scenario, the dotted blue line represents projections under assumptions of weaker growth and the dotted yellow line represents projections under assumptions of stronger growth.
Figure 7: Projections from Riksbank’s first and third Monetary Policy Report of the year, 2007 to 2008. The figures were created by the author using data released by the Riksbank in conjunction with their MPRs and formatted similarly to those contained in the MPRs. The solid red line represents actual results up to the release date of the report, the dotted red line represents forecasts for the baseline scenario, and the fan charts represent confidence intervals. The bands, moving from lightest to darkest, correspond to 50 percent, 75 percent and 90 percent confidence intervals. The black line was added by the author and represents the realized repo rate from the publication of the report until Q1 2009.
Table 2 – RMSE of Norges Bank Interest Rate Projections

<table>
<thead>
<tr>
<th>Projection Horizon</th>
<th>Entire Sample</th>
<th></th>
<th>Projections Realized Prior to Q3 2008</th>
<th></th>
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<td>Reports Only</td>
<td>Latest Publication</td>
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<tr>
<td>2 Quarters Ahead</td>
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<td>4 Quarters Ahead</td>
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<td>8</td>
<td>6</td>
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Table 2: RMSE of Norges Bank interest rate projections. The “Entire Sample” refers projections realized in Q1 2006 to Q1 2009 while only projections realized between Q1 2006 and Q3 2008 are included in the last two columns. The “Reports Only” measures refer to RMSEs generated solely from Norges Bank Reports, while the “Latest Publication” measure uses the latest publication in a quarter, regardless of whether or not it is a Report or an Update.
Table 3 – Riksbank Report and Update Publication Dates

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<tr>
<th>Report/Update</th>
<th>Publication Date</th>
<th>Quarter Classification</th>
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<td>MPR 2007:1</td>
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<td>MPR 2007:2</td>
<td>6/20/07</td>
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<td>MPR 2007:3</td>
<td>10/30/07</td>
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<td>MPU December 2007</td>
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<td>MPR 2008:1</td>
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<td>MPU April 2008</td>
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<td>MPU September 2008</td>
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<td>MPR 2008:3</td>
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<td>MPU December 2008</td>
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<td>MPR February 2009</td>
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<td>2009Q1</td>
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Table 3: Publication dates for Monetary Policy Reports (MPRs) and Monetary Policy Updates (MPUs) of the Riksbank that included interest rate projections. The number prior to the colon represents the year of the report, while the number after the colon is the report number. The Riksbank changed to using release months to denote reports in 2009. The quarter classification is used for the quarter \( t \) in RMSE calculations. 

\(^a\)While technically released in the third quarter of 2008, its close release date to the end of the second quarter makes the report more comparable to one released in the second quarter. See discussion in Section 3.3.2 for more details.

Table 4 – RMSE of Riksbank Interest Rate Projections

<table>
<thead>
<tr>
<th>Projection Horizon</th>
<th>Entire Sample</th>
<th>Projections Realized Prior to Q3 2008</th>
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Table 4: RMSE of Riksbank interest rate projections. The “Entire Sample” refers to projections realized between Q2 2007 and Q1 2009, while only projections realized between Q2 2007 and Q3 2008 are included in the last two columns. The “Reports Only” measures refer to RMSEs generated solely from Riksbank Reports, while the “Latest Publication” uses the latest publication in a quarter, regardless of whether or not it is a Report or an Update.
Figure 8: RMSE of market expectations of NIBOR money market rates. Percentage points. One-quarter-ahead errors are represented by diamonds, two-quarter-ahead errors by circles, three-quarter-ahead errors by triangles and four-quarter-ahead errors by squares. The dates correspond to the quarter in which the projection was made.

Table 5 – Norges Bank P-Values of T-Tests for Differences in Means of RMSEs of Market Expectations

<table>
<thead>
<tr>
<th>Projection Horizon</th>
<th>Entire Sample $H_0$</th>
<th>Alternate Sample $H_0$</th>
<th>Alternate Sample $H_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Quarter Ahead</td>
<td>0.2218</td>
<td>0.0388</td>
<td>0.9806</td>
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<tr>
<td>2 Quarters Ahead</td>
<td>0.4212</td>
<td>0.0036</td>
<td>0.9928</td>
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<tr>
<td>3 Quarters Ahead</td>
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</tr>
<tr>
<td>4 Quarters Ahead</td>
<td>0.5354</td>
<td>0.0413</td>
<td>0.9793</td>
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</table>

Table 5: P-values for t-tests for differences in means of RMSE of market expectations using NIBOR Rates. The entire sample looks at market expectations between Q2 2001 and Q1 2009. The alternate sample compares market expectations from Q4 2003 to Q2 2008. The publishing period begins in Q4 2005. The null hypothesis, $H_0$, is that the mean RMSE of market expectations is equal before and after publishing interest rate projections. Differences in variances of the periods was tested using an F-test, then the appropriate assumption about equal or unequal variances used for the t-test. The alternative hypothesis, $H_A$, tests if RMSEs in the period after publishing are less than the RMSEs in the period before publishing.
Figure 10: Mean daily absolute change in market interest rates in response to announcement of interest rate decisions. Percentage points. Absolute changes in rates are calculated from 12:00 P.M. the day of the decision to 12:00 P.M. the following business day, from which mean daily absolute changes are calculated. Interest rate decisions are announced at 2:00 P.M. NIBOR Rates refer to NIBOR money market maturities of 1 week to 12 months. The range of rates refers to NIBOR rates plus 3-year government bonds.
Table 6 – Norges Bank P-Values for T-Tests for Differences in Means of Absolute Changes in Response to Interest Rate Decisions

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<th>Adjusted Changes</th>
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<td>Range</td>
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Table 6: P-values of t-tests for differences in means of mean absolute daily change following interest rate decisions, Q2 2001 to Q1 2009. The mean daily absolute change (see Figure 10) is used to test for differences in means before and after publishing projections. The null hypothesis tests if means are equal before and after publishing, while the alternate hypothesis tests if the mean is less after publishing.

Table 7 – Riksbank P-Values of T-Tests for Differences in Means of RMSEs of Market Expectations

<table>
<thead>
<tr>
<th>Projection Horizon</th>
<th>$H_0$</th>
<th>$H_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Quarter Ahead</td>
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<td>2 Quarters Ahead</td>
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<td>3 Quarters Ahead</td>
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<tr>
<td>4 Quarters Ahead</td>
<td>0.421</td>
<td>0.7895</td>
</tr>
</tbody>
</table>

Table 7: P-values for t-tests for differences in means of RMSE of market expectations using STIBOR Rates, Q2 2001 to Q1 2009. The publishing period begins in Q1 2007. The null hypothesis, $H_0$, is that the mean RMSE of market expectations is equal before and after publishing interest rate projections. Differences in variances of the periods was tested using an F-test, then the appropriate assumption about equal or unequal variances used for the t-test. The alternative hypothesis, $H_A$, tests if RMSEs in the period after publishing are less than the RMSEs in the period before publishing.
Figure 11: RMSE of market expectations of STIBOR money market rates. Percentage points. One-quarter-ahead errors are represented by diamonds, two-quarter-ahead errors by circles, three-quarter-ahead errors by triangles and four-quarter-ahead errors by squares.
Figure 12: Riksbank repo rate, January 1998 to March 2009. Monthly average. Percent.

Table 8 – Riksbank P-Values for T-Tests for Differences in Means of Absolute Change in Response to Interest Rate Decisions

<table>
<thead>
<tr>
<th>Rates</th>
<th>Absolute Changes</th>
<th>Adjusted Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$H_0$</td>
<td>$H_A$</td>
</tr>
<tr>
<td>STIBOR</td>
<td>0.0745</td>
<td>0.9627</td>
</tr>
<tr>
<td>Range</td>
<td>0.0699</td>
<td>0.9651</td>
</tr>
</tbody>
</table>

Table 8: P-values of t-tests for differences in means of mean absolute daily change following interest rate decisions, Q2 2001 to Q1 2009. The mean daily absolute change (see Figure 13) is used to test for differences in means before and after publishing projections. The null hypothesis tests if means are equal before and after publishing, while the alternate hypothesis tests if the mean is less after publishing.
Figure 13: Mean daily absolute change in market interest rates in response to announcement of interest rate decisions. Percentage points. Absolute changes in rates are calculated from 11:05 A.M. the business day prior to the decision’s announcement to 11:05 A.M. the business day following the announcement, from which mean daily absolute changes are calculated. Interest rate decisions are announced in a press release at 9:30 A.M. STIBOR Rates refer to STIBOR money market maturities of 1 week to 12 months. The range of rates refers to STIBOR rates plus 2-year government bonds.
References


